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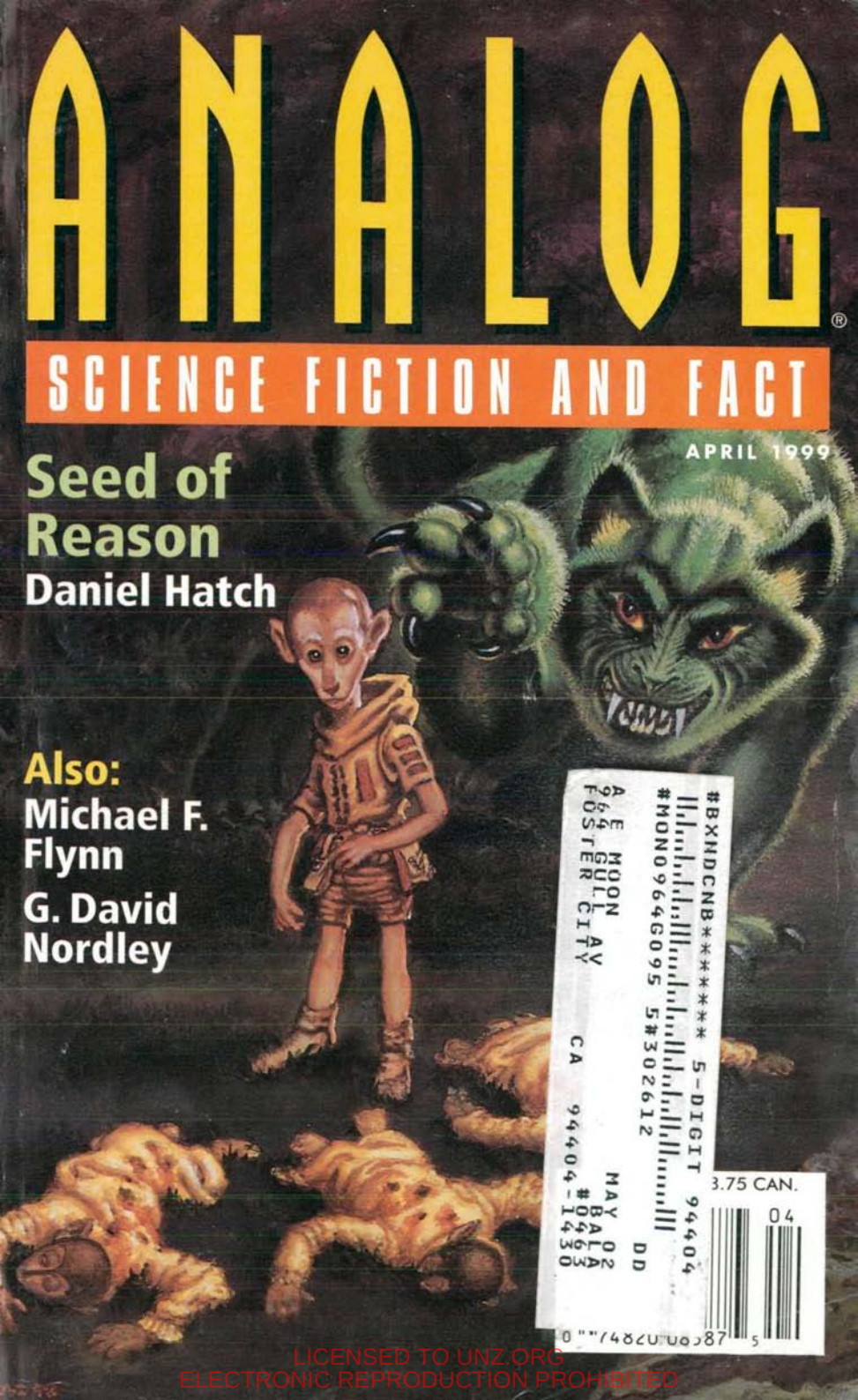

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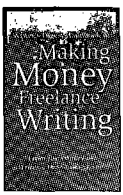

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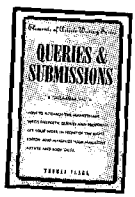

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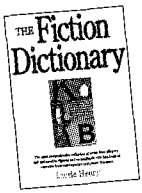

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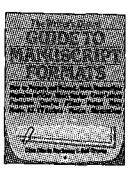

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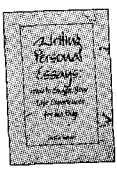

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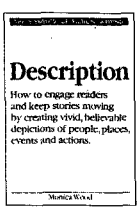
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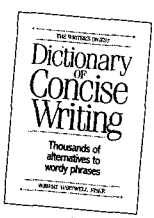

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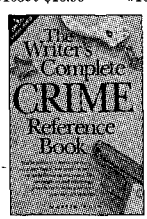

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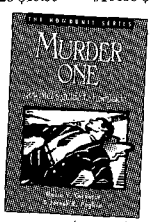

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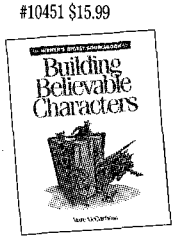

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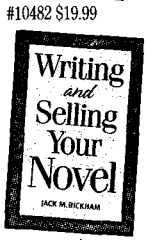

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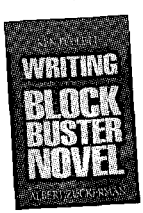

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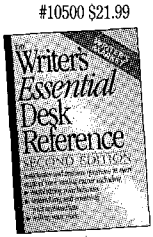

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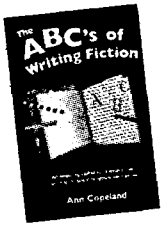

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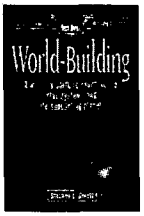

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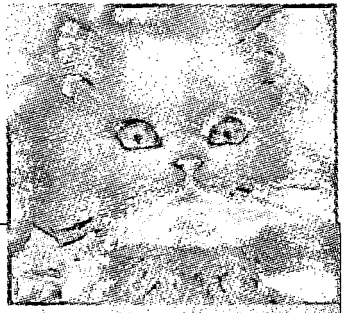

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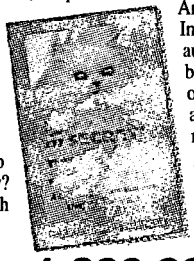

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EDITORIAL Stanley Schmidt

RIGHTS VS. RIGHTNESS

Sometimes essayists, like dentists, hit nerves. Dentists usually aren't trying to; essayists often are—but sometimes we hit nerves we weren't even aiming for.

For example, in my September 1998 editorial, "Invisible Enemies, Intelligent Choices," I ended with the words, "Decisions that affect everybody are everybody's business, and the idea that anybody's opinion is as good as anybody else's just doesn't hold water." That drew letters from a number of readers who said they agreed with what I said but felt uncomfortable with the implications.

Well, good. That has long been one of the purposes of *Analog* editorials: to show up inconsistencies in people's beliefs by leading them down one path of reasoning to a conclusion that they want to reject. Ideally, the resulting discomfort should force them to resolve the conflict by thinking about which belief they *really* hold—or whether they need to reject both in favor of a third alternative.

In this case, I wasn't trying to say or imply anything about forms of government. I was simply stating a simple, irrefutable, almost self-evident fact: a right opinion (one that matches reality, such as "Fire burns") is worth more than a wrong one (one that doesn't match reality, such as "Fire has no effect on flesh"). But I'm glad some readers went beyond what I said to draw a disquieting conclusion about government.

That conclusion they drew was that, if all opinions are not equally valid, and good decisions must be based on valid opinions, then the ideal form of government must be a meritocracy, with decision-making limited to people who understand the issues. This disturbs people because it seems incompatible with the belief that all men and women are equal and should have an equal voice in government. As a particularly articulate reader named Beth Clarkson put it, "[the statement that all opinions are not equally good] is absolutely true. On the other hand, I have serious problems with anyone wanting to tinker with the idea of universal equality as the philosophical basis of our society. . . . America is founded on the . . . belief that 'all men are created equal.' This is a belief I hold quite dear despite its obvious falsity. I feel that a society in which people, and their opinions, are not considered equal is a society with a potential for abuse, injustice, and bad decision-making that is far worse than that incurred by the pretense that such a belief is true."

Well, maybe. Certainly there is potential for abuse and injustice in a society that considers some of its members' opinions worth more than others because of who holds them—particularly if it acts on that view by disenfranchising certain classes of people. Whether the danger inherent in that abuse and injustice is worse than those inherent in decisions being made by ignorant masses is debatable and likely to vary from case to case.

And disenfranchising certain classes of people is not necessarily implicit in what I said, anyway. That inference depends on one or more hidden assumptions: that a meritocracy has to be small, and/or that the only way to keep igno-

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rant voters from running the show is to disenfranchise them.

Quite likely that's enough hint that you can see where I'm heading, but please let me spend a little longer sneaking up on it.

We have two principles in apparent conflict:

(1) If decisions are going to significantly affect the lives of many people, it's important that they be made on the basis of a sound understanding and analysis of the factors involved. In short, decision makers should understand what they're deciding about—which, ever more, means not only following the news and commentary in the media, but understanding something about how the physical and natural world, and the technology we've derived from it, works.

(2) If decisions are going to significantly affect the lives of many people, it's important that all the people affected should have a voice in making them. In short, everybody has a right to vote.

So which is more important: the right to vote, or the need to be right?

Ideally, many of us might say that *both* are highly important. In practice, we might recognize that any crowd of voters will include some who *don't* know enough to make a well-informed decision. So do we have to choose between entrusting our most important decisions to a small "elite" and entrusting them to a mob that, as a group, may have no idea how to make a rational decision?

At first glance, it would seem that we do. Hence the discomfort of my correspondents. Decisions like whether to dump raw sewage into our rivers (or, in a representative government, to elect people who are likely to do so) really *can* do tremendous damage to everybody, so it *is* important that they be made sensibly. But if we try to round up all our citizens who understand chemistry and ecology very well, and have them decide for us—the "meritocracy" my correspondents fear—we run just as great a risk of their abusing their power because the rest of us don't know enough to keep tabs on them.

Both dangers are serious. It's not clear that either is categorically more dangerous than the other.

So is there a way we can guard against *both*?

I think there is. The fact that my correspondents didn't mention it suggests to me that too many of us have given up on public education—and that's something we don't dare do.

Because general education that *works* is the one and only way I can see to head off both dangers at once.

I recognized the fundamental dilemma in "Invisible Enemies, Intelligent Choices," when I wrote, "An interesting problem, of potentially life-and-death significance, can and does arise in such decisions: what if an ignorant majority believes it's perfectly all right to dump untreated sewage in the water supply, but an informed minority knows it isn't?"

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The answer is implicit in the question. If an ignorant majority is allowed to do something that will hurt everybody, then everybody is in trouble. If an informed minority is allowed to impose its desires on everybody else, everybody will quite likely soon be in a different kind of trouble.

Therefore our major decisions cannot safely be entrusted to *either* ignorant majorities or informed but self-interested and autonomous minorities.

Which leaves only one alternative: we *must* have an informed majority. A radical proposal, I realize, but the fundamental presumption of a successful democracy is an *informed, interested* electorate. Merely letting everybody vote, even if they know nothing about what they're voting on, provides absolutely no assurance of generally beneficial decisions. I seriously doubt that you would want your plumbing or dentistry done by a committee of people who know nothing about plumbing or dentistry. The folly of that is self-evident to most of us, yet we do very much the same thing when we let important decisions about the whole country be made without regard for whether the decision-makers know what they're doing.

If we want to stop doing that, we have two choices. We can abolish democracy and turn the decision-making over to panels of "experts," and hope that they're as interested in our welfare as in their own; or we can make a real, serious effort to make sure that most voters do know what they're doing.

There are at least two possible variations on that theme. One approach is to establish some means of requiring citizens to demonstrate minimal knowledge and competence as a prerequisite for the right to vote. This amounts to a meritocracy, as my correspondents feared, but it's a somewhat peculiar meritocracy: anybody can join it. All anyone has to do is take the trouble to learn enough to pass the test, whatever form it may take. There's no limit on size, and in principle this meritocracy could include the entire population.

In practice, of course, you could never get the experiment tried in today's social climate. (I won't say "never" in any broader sense, because all kinds of things have already happened in American society and politics that earlier generations would have found inconceivable.) Any sort of proof of competency would surely be compared to the literacy tests used in some of the darker episodes of our history to keep minori-

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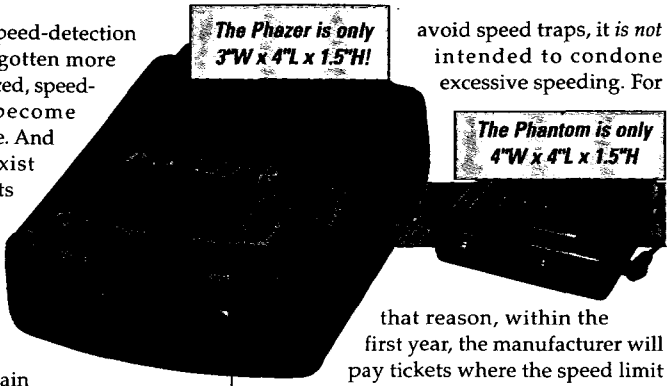
How to make your car invisible to radar and laser

Rocky Mountain Radar introduces a device guaranteed to make your car electronically "invisible" to speed traps—if you get a ticket while using the product, the manufacturer will pay your fine!

It seems that as speed-detection technology has gotten more and more advanced, speeding tickets have become virtually unavoidable. And although devices exist that enable motorists to detect these speed traps, they are outlawed in many states...including mine.



The solution. Today, Rocky Mountain Radar offers drivers like me a perfect solution—the Phazer. The Phazer makes your automobile electronically "invisible" to police speed-detecting equipment. The radar component works by mixing an X, K or Ka radar signal with an FM "chirp" and bouncing it back at the squad car by way of a waveguide antenna, effectively confusing the computer inside the radar gun. The laser component transmits an infrared beam that has the same effect on laser Lidar units.

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ties from voting. The cries of "Racially motivated!" would be so strident that you couldn't get anybody to listen to the motivation, or to suggestions for reducing or eliminating any ethnic side effects.

Which leaves us, in practice, with the *other* variation on How to Get Lots of Knowledgeable and Reasonable Voters: don't disenfranchise anybody, but increase the number of well-educated voters to the point where they can win elections by sheer force of numbers. That's not easy either, but it's what we need to do. It's a daunting prospect, when you consider the mess that constitutes so much of public education today, and the fact that the popular image of a well-educated person is inherently a caricature.

But consider the alternative: if we *don't* make a majority of the voting population take their job seriously, and learn enough to do it well, *you* are going to have life-and-death decisions about your future made by people who are incompetent to make those decisions. So *you*—no matter who you are—have a vested interest in making it happen. That will require improving schools throughout the land, even in such drastic ways as abolishing the concept of self-esteem as a birthright instead of something to be earned. I don't mean just rich people's schools or white people's schools or black people's schools; I mean *everybody*'s schools.

But it will take much more than that. It will also require changing *attitudes* throughout the land. We need to make being smart something for everyone to aspire to, not to ridicule. We need to show at least as much respect for somebody who can write an outstanding novel or explain something that's never been understood as for somebody who can hit a ball over a fence a lot of times in one season. The other side of the same coin is that willingly *not* learning should never be seen as "cool," but as stupid and pathetic. Social pressures in school need to be supportive, encouraging people to stay in and get all they can from the available resources. (Or get out and get all they can from the available resources. I'm well aware that some people learn better outside school than in it; the important thing is that we all need to learn, and keep learning, however we do it.) We must stop treating education as a low-stakes game, and start treating it—and voting—as serious business where *results matter*.

And none of us should be shy about pushing things in that direction. It *is* our business; every vote cast in ignorance hurts *us*. Changing such attitudes may seem a tall order, but it has been done in other areas. Look what's happened to the social status of smoking in the last couple of decades. If enough people want it to, it can happen to attitudes toward learning and citizenship, too. We can have both universal suffrage and intelligent government, but that's the only way I've thought of to get them.

And how many things can you think of that we need more? ◙

> Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it's the only thing that ever has.
>
> —Margaret Mead

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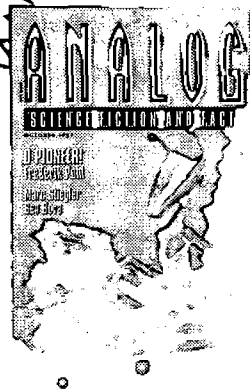

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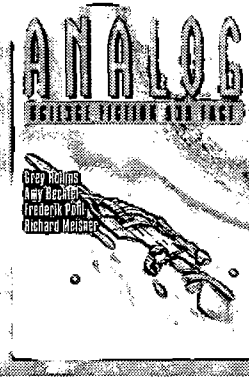

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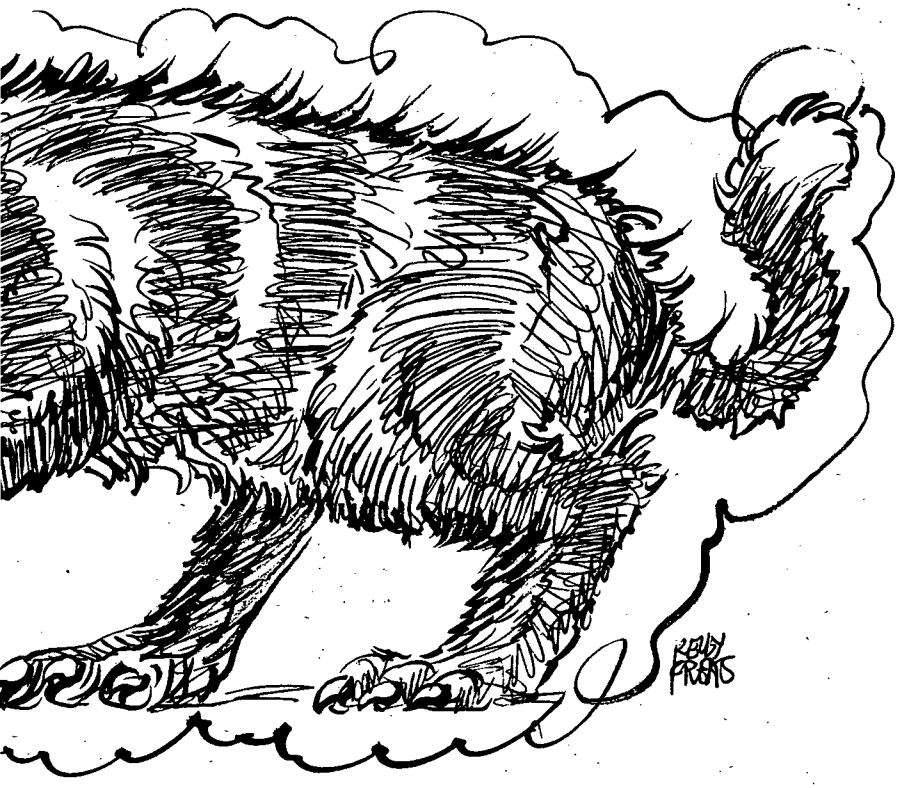

Daniel Hatch

SEED OF REASON

Some jobs, once started,
just can't be abandoned. . . .

Illustration by Kelly Freas

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H'Ree t'Fugguls opened his shorts, lifted one leg, and spattered the bole of the great tree with yellow water.

As its steam rose in the viscous mid-morning humidity, he listened to the rainforest—dripping water, rustling leaves, the peeping of eighty-eighty-eight frogs in joyous chorus, the hoot of the wild halflings in the shadows.

"Pee high and hide your poo," his breed-father had always taught him. The old dog knew what he was teaching; the advice had served H'Ree well over the years.

He picked this tree because it was well-served as a target. He counted the scents of a dozen different breeds that had passed this way since yesterday's rains. The Pelagi Road had become much busier in the last couple of days. Something was up, but he didn't know what.

He should find out; one of the duties a Pilgrim of the Way was to investigate the unusual. But another was to survive long enough to report back. His personal inclination was to avoid trouble—no easy task in the heart of the tropical jungle.

Now trouble came as a shaft of sunlight working its way through layer upon layer of forest canopy, aided by the roadbed's opening behind him. The light was halved and halved again by its passage, yet sufficed to catch the bright yellow cloth a few steps inside the thicket.

H'Ree froze. He stroked the long whiskers that trailed from his short snout and sniffed the air. A chill ran up his back and its fur stood up as he caught the scent of blood.

Every primitive impulse in his all-too-primitive body screamed at him to run away. But his wisdom was the master of his wildness, and he pressed through the underbrush into the small clearing.

The bodies wore the same bright yellow, smeared with dark blood at the tears in the cloth. All three were smaller than H'Ree, with wide hands and snouts and big ears.

He was about to take a closer look when he realized with a start that he was not alone. The fur rose again across his back at the sound and scent of the other.

H'Ree turned slowly to his left to look into the eyes of a tree-cat less than a dozen hands away.

She was big and she smelled of vinegar and ammonia, and she was close enough not to care how much noise she made. Her fur was dark green, though it shone like an emerald where the sun spilled onto it. The muscles in her forearms swelled beneath taut skin, her long tail twitched erratically, and an ominous, deep purr rumbled from her throat.

H'Ree's blood froze in his veins. He felt his livers tighten up. His back arched involuntarily. He steeled himself in wait for the cat to make its move—to pounce or swipe or even snarl.

"Diggers, aren't they?" the cat asked. "Strange how in death they become so unfamiliar to the eye."

Mark Paradis stood on the wide verandah of the great wooden tree house and surveyed the work of years while his wife paced angrily behind him.

The transmitter hummed with power high up on the hill as the AI replayed the day's lesson in yet another chamalian dialect. The garden below the house was finally beginning to flourish, after careful tending and a protracted battle against local parasites and diseases. The barn and the barnyard were full of happily domesticated creatures, both wise and wild, halflings, steplings, and half-grown wiselings, who played and worked together. And the great squares of plastic and aluminum that held Alysa's frog farms glistened in the bright morning sunlight. All of it was now cast into uncertainty.

"The man's a physicist, for god's sake!" Alysa Spenskaya cried as she came

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back out onto the verandah. "How can he possibly pass judgment on us?"

Mark shrugged, then said the wrong thing: "He's a scientist, love. They want someone outside your specialty to make sure the assessment is objective."

By now, however, any attempt to explain things to Alysa only made her suspect he was defending them. And she was in no mood for conflicting loyalties. Luckily, she just glared at him for a second, then she stalked back inside.

"If you hadn't stirred everyone up with your endless textwars, this never would have happened," Alysa called out.

He winced, but said nothing. This was not the place for that argument. The textwars were just a consequence of their current dilemma, whose roots went deep and had been there a long time. It was just the nature of Chamal. It was a hard world to understand, harder to explain, and harder still to accept.

And now the auditor was coming.

"Why are you just standing around?" Alysa asked on her next pass outside. "Why don't you do something?"

"There isn't much left to do," Mark said. "The place is clean and tidy, the records are complete. We've even bathed the frogs. I don't know why you're getting all worked up like this. We've known for two months that he was coming."

"Yes, but he's going to be here today!"

"I know that, dear," Mark said. "And there's nothing left to do now but welcome him and invite him in. We can explain things to him. We can show him what we've done. We can answer his questions. And then we can send him on his way back home."

"Answer his questions?" Alysa stopped suddenly and swung to face Mark. "How are we going to answer his questions? I can't answer my own questions, and I've been working on this problem for years. Whenever you start to 'explain things,' you begin babbling about 'Pilgrims of the Way' and 'cultural diversity.' Neither one of us is capable of presenting a case for our research that the other can't poke full of holes. How in the world are we going to hide that from this . . . this auditor?"

"You just need to have more faith, Alysa," Mark said, trying to deflect charges.

"Faith? My whole career is about to get flushed down the sewer and you want me to become spiritual. That's so typical of you."

"Then try exercising some self-control," Mark snapped at her. "He'll be here in a few minutes, and if he finds you climbing the walls, he's going to start off with precisely the wrong impression."

That seemed to get through to her. For a moment. But then she spun on the ball of her foot and stormed deeper into the house, emerging from the rear porch and ascending the steps to their sleeping quarters in the tree's higher reaches.

Mark remained alone on the verandah to await the auditor's arrival.

H'Ree dared to take a breath. His head swam dizzily as the oxygen returned. His tongue was thick, but he swallowed and regained control of it.

"I was thinking just the same thing," he said, keeping his voice steady. "Diggers. The yellow dresses make it certain. Their wild folk root for mud potatoes along the riverbanks. Their wise folk make their homes in a dozen small villages above Twin Falls where they weave and dye their cloth."

The words sounded false and distant, as if uttered long-distance by some virtual creature, one that didn't see cruel death itself only an arm's reach away.

"Have you traveled far?" the cat asked.

"I've been walking the Pelagi Road since dawn," H'ree replied. "Before that, I came up from the Pilgrimage House at the great roo. I'm on my way to the highlands beyond Purple Frog Lake, north of where the Angels make their camp."

"The Angels? Is this a new breed?"

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"They came here from heaven itself more than a halfling's age ago to a clearing on the side of the old Toko volcano. They put up a great house in a nakok tree and began broadcasting their wisdom over the radio. And breeding frogs."

"Breeding frogs?" The cat hissed. H'Ree felt his bladder grow weak, but it seemed the hiss was an expression of amusement. "What a silly thing to do. There are much better-tasting things to eat in this jungle than frogs. Even for angels from heaven itself."

H'Ree shuddered at the thought. "No one could imagine why they would breed frogs when they first came—no one but the Pilgrims of the Way."

"And what special knowledge do the Pilgrims possess?"

"The First Pilgrim, Jobe himself, learned the ways of the Seed of God by studying at the side of a frog-breeder more than forty-eighty-eight years ago."

"He did?" the cat hissed. "What a wise and clever creature he must have been."

H'Ree felt suddenly ill. The cat was playing with him. He had made the error of being boastful when he could have remained circumspect. He wondered if this would prove fatal.

"I know what you're thinking," the cat said. She licked the fur on the back of one hand and rubbed it behind her ear. "You are thinking that I killed these diggers and that you're next. You are wondering if I'm going to think that three little diggers are plenty of supper without throwing in a tough old hound like you. You are afraid that your very brief pilgrimage in this sorry world is at an early end. Aren't you?"

H'Ree was paralyzed with fear. He stuck his chin high and clenched his teeth.

"Admit it, little wiseling," the cat insisted. "An end to all suffering awaits you, and you face it with terror when you should embrace it."

"I admit nothing," H'Ree said. "I am a Pilgrim of the Way. I make no conclusion until its time comes. I pass no judgment without evidence. And I admit no error where none is made. Truth be told, I was thinking that you are less frightening to me than the Angels. While you have the power to bring my death, they hold the power to bring death to every creature on this planet. Consider that the next time you grow hungry."

"Well, you're wrong," the cat snarled, ignoring his words. "Look at these poor unfortunates. Examine their wounds. This is not my work."

H'Ree tore his eyes away from the long white fangs that the cat now bared and the black knives that extended from her fingertips, and looked more closely at the dead diggers.

The yellow clothes were black with powder burns. The blood oozed up from a dozen small holes. All three lay face down on the ground in a row, with no signs of a struggle in the brush. Someone had ordered them into the thicket, made them lie down, then shot them in the back.

The cat was right about that, at least.

Dr. Arthur Benz arrived with a bone-jarring thunderclap of the orbital lander's sonic boom. The screech of tortured air split the sky as the lander swooped low. It circled once and came down on the broad landing field downhill from the camp.

Mark hurried down the stairs and jumped into the cart to meet him. Alysa was still in her quarters when he left.

Benz was a tall man with a shining pate, a thick brown beard, and an archaic-looking pair of spectacles perched on a round nose. He squinted against the sunlight, and stepped down the ramp from the lander onto Chamalian soil for the first time. He seemed a bit unsteady: his legs kept rising up in a comical high-step. It was a common problem for newcomers to the planet, whose gravity was slightly lower than Earth standard.

He sported a broad grin and a somewhat embarrassed expression over his awkward gait.

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"I didn't quite realize it was another planet until I tried walking," the auditor said as Mark took his bags and helped him into the cart.

"Don't feel bad," Mark said. "Everyone goes through it at first. Your legs have to relearn their timing in order to keep in touch with the ground. But you're right about one thing—this really is another planet. Especially out here in the boondocks, away from the bright lights and big cities."

"So I understand, Mr. Paradis. I've read some of your texts. A very intriguing planet, to say the least."

"Would you like me to show you to your room? Or would you rather have a tour of the place before the rains come?"

"Oh, the tour, by all means," Benz replied, craning his neck to look at the tree-house. "I've been cooped up inside tin cans ever since I left Earth eight weeks ago. And then three days in orbit here aboard the *Cousteau* getting pumped full of antihistamines and vaccinations. I'm somewhat overwhelmed by the sudden change. It's almost intoxicating."

"Well I hope you enjoy it, then," Mark said. One of us should.

"Once upon a time, before there were machines, my tribe owned this land," the cat said softly. H'Ree strained to hear, but fought the urge to lean closer to those deadly fangs and claws. "Before the Bakamaru built their kingdom of iron and coal, before the Pelagi built their empire of stones, before power came from wisdom instead of strength, we ruled the forest."

She preened herself as she puffed up her chest. "But ours is a world of powerful ironies. We learned its most important lesson before all the others did."

"Nothing lasts forever," H'Ree said.

"Nothing. All power is fleeting. Use it while you have it, because it is only yours to brush, not to grasp. We learned before the rest how to fall from grace. And we have watched from the forest for eights of eighty-eight years as each tribe has fallen. The way is always the same, through blood and fire and death."

"Whose power is fleeing from them now?" H'Ree asked, guessing at the cat's point. "Surely not the Bakamaru."

"Surely not," she hissed scornfully. "But their neighbors are not as fortunate. Time has run out for them. The Bakamaru are expanding. In the past shortmoon, they have taken new lands. First they moved south and took the forests east of Prince Akan's Roo. Then they moved west and took everything up to the banks of Purple Frog Lake."

"Those lands belonged to the Tornoks and the Swince."

"They still have land, just not as much. It's not as if someone ate them all," the cat said.

"They worked as hard as they could to feed themselves on the land they owned," H'Ree protested. "How will they do so on less?"

The cat shrugged sinuopusly. "Some are hunters, others are hunted. The numbers sort out over time. In any case, the lands now feed the furnaces of the Bakamaru, who make more black metal each day."

H'Ree shuddered. The hunger of the steel-makers for coal and iron was well-known in this part of the forest. Many lands had fallen under their control, as the steel was used for weapons, and the weapons used to raise armies. The pattern was always the same. They came through a region like a wildfire, overwhelming the locals, setting the torch to their homesteads and villages, driving all before them in a great wave of misery.

The coming of the Angels had put an end to that for a time. It was one of their commandments. But if small empires were on the march once again, that could only alarm the Angels and sadden H'Ree. But not, apparently, the cat.

"You seem amused by their misfortune."

"They are no friends of mine. Even

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their meekest hunted my kind with a vengeance that no wild beast ever knew. To see them fall before great power gives me satisfaction. And in the end, the meekest among them may rise up against the Bakamaru as well."

"A strange source of pleasure," H'Ree noted. "Not one I can appreciate."

"You must acquire a taste for irony," the cat said.

"A tolerance, perhaps, but not a taste," H'Ree replied.

"Psssst! Your breed is too young to know what the world is about. Look at this. What is death but the ultimate irony? What hopes and dreams ended in this thicket with these three?"

H'Ree looked down at the bodies again and held back pangs of loss. Then he turned his attention again to the cat. "The Swince and the Tornok do not use firearms. These diggers were shot. There is more going on than you've told me, isn't there?"

The cat purred loudly and licked her paw. H'Ree was sure he detected a smile in the dark folds of her furry face.

"The F'Tan," he said.

Alysa wouldn't come out of her quarters.

"Tell him I'm busy," she said. "Tell him I'm involved in delicate research.

"Or tell him that I'm just being temperamental and you all have to put up with it."

"Yes, dear," Mark said. "Will you be down for supper?"

"I'll let you know when the time comes," she said.

He made his way down steps carved from live wood and across the verandah to the main room, where Dr. Benz sipped a cold lemonade.

"I'm sorry," he said when Mark made his apologies for his wife. "I hope I'm not causing too much of a disruption in your work. I know how difficult these inspections can be for everyone involved."

"She's just very busy," Mark said. "And no matter what you do, it's hard to get used to the seventeen-hour days. There's never enough time to do anything, and it's far too easy to stay up all night long working."

"I'm sure it must be difficult," Benz said. "I was just admiring the craftsmanship that obviously went into your home."

The house Mark shared with Alysa was cradled in the limbs of the great tree, which spread wide in their search for living space—so wide that they had to send down new trunks to support their weight. This tree was more than fifty meters across from one end to the other and rose nearly that high above the ground on more than a dozen trunks. In addition to the main building, they had built several free-standing cabins around the perimeter—their bedroom, a library and office for each of them, and guest quarters for special visitors (the grad students stayed in a bunk house down by the labs).

"It was all done by local craftsmen," Mark said. "The Tornok monkeys are expert carpenters and the hand-carved woodwork was done by bush-climbers from Kleeklax."

"I assume the decorative scrolls here were their work," Benz said. He pointed to the heavy rail that surrounded the verandah, where the twisted faces of Kleeklax night demons scowled out at the world.

"The chamalian imagination is full of dark visions and hidden depths," Mark said.

"So I've read," Benz replied, peering uncertainly at the alien grimaces.

"Anyway, as long as Alysa is indisposed, I can give you the cheap tour of our camp," Mark said. "We should have time before the rains come through."

As he led the way back down to the cart, he looked up to see Alysa glaring down at them from the door to their quarters high above.

"The F'Tan are swine," H'Ree said.

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"Be that as it may," the cat said, "they are also well-armed swine. Their hands are not so fat that they cannot grip the stock of a Meshkari needler or an Arkarian slug-thrower. And they have sifted enough gold out of the rivers in their lands to buy quite an arsenal."

"And now they're putting it to use?"

"Yes indeed," said the cat. "The F'Tan are a young tribe. They've only recently come into wisdom and lack the seasoning of older breeds. They are easily upset. The sudden movements of the Swince and the Toroks have set them on edge. Even though no one has invaded their territory, they are moving west, driving before them all the wise breeds who would oppose their expansion."

"As I recall, the F'Tan also reject the teachings of the Pilgrims of the Way."

"If you mean they do not believe that all creatures who possess the Seed of God are equal, then that is true. But they are not alone in that."

"Perhaps. But being right has its own advantages."

"True. But merely believing you are right has its disadvantages."

H'Ree ignored the veiled affront and countered with a question: "Are you saying the F'Tan killed these diggers?"

"These and many more. The blood scent is thicker the deeper you go into the wood. And the night echoes with the pop of their weapons. The F'Tan are not a courageous breed. They do not press east towards the Bakamaru."

"The merchants in Meshkar refuse to supply them with rockets and death-rays, but they make up in numbers for what they lack in firepower," H'Ree said. "Though that lack may spare them in the end."

"Spare them? From what?"

"From the wrath of the Angels," H'Ree said. "The word has spread wide, but I'm afraid it has not taken deep root."

"And what word is that?"

"That the Angels will allow no more genocide on our world. If breed takes on breed, if the wise prey on one another like the wild, then the Angels will step in and put an end to it. Even if that means eliminating every creature, wise and wild, in the world."

"That seems an ironic approach," the cat said. "Are you sure these Angels are not of our world?"

"Not at all," H'Ree said. "They are purebreds. Their breed is the Seed of God itself. They are only wise and never wild."

The cat hissed in surprise. "They are not likely to retain their purity long in this dark forest," she said. "They say this jungle is the place where God was cast from the Garden after being raped by the wild creatures who stole his seed."

"I would wager against that," H'Ree said. "They are not just pure in seed, they are pure in heart. Their wisdom is far beyond anything our world has ever known. And they broadcast it over the radio day and night."

"Those are bold claims," the cat said. "I have a hard time swallowing that meal."

"Swallow it or not, truth is truth," H'Ree said.

The cat yawned and stretched, arching her back and exposing her claws. H'Ree felt the fur rise on his back again.

"In any case, it is drawing close to my dinnertime," she said, twisting H'Ree's nerves ever tighter. "And these poor unfortunates make an even poorer repast. I prefer to play with my dinner before I eat."

"If you are speaking of me, then I'm afraid you would find the meat on these old bones far too tough and far too dry to please your appetite."

"If I were speaking of you, you would not have time to debate the point," the cat said. "Though the idea has its merits. Perhaps as an appetizer—"

H'Ree readied himself to spring away as his lips curled themselves back to bare his own sharp teeth. But the moment was interrupted.

Pop!

Pop-pop-pop!

H'Ree and the cat both turned to-

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wards the inner forest where the sound of gunfire echoed.

The leaves above them shredded with loud confusion as projectiles tore through the air.

"The F'Tan!" cried the cat as he leapt towards a tree.

"Seed of God!" cried H'Ree as he leapt towards the road and away from the shooting.

They got as far as the frog farms before the rains came in.

The sky darkened, the air thickened, and fat drops of water splattered across the yard, advancing like an approaching army and chasing Mark and Dr. Benz through the doors.

The rain drummed hard on the aluminum roof, amplifying the violence of the storm. But it wasn't enough to muffle the thick chorus of peeping that seemed to come from everywhere.

"So this is the biological section of the research station?" Benz asked.

"We have a couple of acres under this roof," Mark said. "More than two hundred compartments. And we're growing all the time."

He led Benz down the hall between walls of plastic sheathing, treading on a bituminous floor. At the first door, he paused, inspected the information on the security card. "We can look inside here," he said.

The chamber was not much larger than a bedroom, with a low-walled plastic enclosure taking up most of the space. Inside the enclosure was a perfunctory terrarium—a shallow pool, rocks, and thick grass in the corners. The peeping of its inhabitants was sharper and much clearer in here. They leapt and swam and cavorted in their miniature piece of jungle. Overhead, a network of hoses and pipes channeled captured rainwater into a sprinkler that mimicked the climate outside.

"I see green ones and blue ones," Benz said. "Is that significant?"

"According to the chart on the door, they're emerald and cyan, but Alysa says men can only see six colors, so I'm with you. The blue ones are the dominant genotype, and the green ones are the subordinate. But the thing to remember is that they both hatch out of the same egg masses. Blue mothers produce blue and green frogs, green mothers produce green and blue."

"And what's this red one over here?" Benz said, pointing at a bright outsider in the grass in the corner.

"Crimson," Mark said. "That's one of the sports."

"And how many per generation are sports?"

"That's the magic question," Mark said. "After a few generations, you can have the sports take over the whole population. Or they can stay dormant for a hundred."

"And how long is a generation?"

"A month. That's what makes them so useful for genetic studies."

"And you're sure the higher animals follow the same pattern?"

"Theoretically, they'd have to. They evolved straight up from the frogs—skipped the reptile and bird phases. But we've got documentation from the Seedkeepers of Suridash that confirm the basic patterns of heredity. They've got records in the city that go back more than three centuries."

"What kind of patterns? Mendelian genetics only talks about dominant-recessive pairs. I understand chamalian genetics are more complex."

"Much more complex numerical patterns, of course. A lot of high-binary stuff—fours, eights, sixteens. The early Seedkeepers made a lot of mysticism out of it, but they were religious in their recordkeeping too. That's saved us years of work.

"You'll see traits skip a generation and then come back, again and again, until something turns it off and they take a different path. Or they'll skip sixteen generations and then blossom and

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take over a population. Come on down here and I'll show you."

He led Benz out the door and headed down the hall.

"In here is where it gets interesting," he said. "When the enclosures are big enough, you'll see traits stabilize across the whole population, but wander from one part of the population to another."

They entered a much larger chamber with a stand of low trees pushing up against the plastic roof at one end and a series of ponds and rockpiles distributed chaotically around the broad floor.

"This was our first big lab," Mark said. "The plumbing overhead also contains a video monitoring system. There's more than a hundred cameras up there, but the computers put it all together in a single image. We can track individuals, groups, whole populations."

"How do you tell them apart?" Benz asked.

"Well, I wanted to go in and tag each one of them with little ankle clips, but Alysa developed a radioactive isotope tracer that can be identified from above. That way, we can track egg masses as well as individuals. And by varying the makeup of the isotopes, we can mark different groups. That's how we documented the genetic drift in our first round of experiments."

"Oh yes," Benz said with a smile of recognition. "I've read about all this, but now I understand how you do it."

"This enclosure contains a dozen separate habitats and as many different breeds of frog—tree peepers up there, rock hoppers over there and there, and colored frogs in the various pools. Each habitat is separated by a low threshold—enough to prevent incidental mixing, but not to block a determined effort. And we've watched how the populations changed for years."

"And you've seen the traits drift?"

"It's an amazing thing to watch," Mark said as he nodded vigorously. "They're very persistent, shifting from population to population over the generations. Colors move the easiest. But the pads the tree peepers use to climb trees show up on the rock hoppers a year later. Then you find them on the pond frogs—for what purpose I can't imagine, since they make it harder to swim. One year the peepers ended up with webs and flukes and kept falling out of the trees. You can watch the traits wander back and forth on the computer sims, like little gyroscopes spinning on a table, back and forth chaotically."

"But underneath it all there's a certain measure of proportionality," Benz said.

"Exactly," Mark said in agreement. "Come with me."

He led Benz out into the hall once again and headed deeper into the complex. "You don't have any idea how unified nature is until you see something like this. It's hard to believe that a chain of evolutionary accidents could produce something so devious."

They stepped into a smaller version of the great chamber. A single tree rose from the edge of a small pool, a pile of rocks on the far side, and tall grass filling in around the perimeter.

"A couple years ago, we took our prize stock—a breeding population that had shown nearly fifty percent self-replication for more than ten generations."

"Only fifty percent?" Benz asked in surprise. "What does that mean, exactly?"

"It means that each generation these Three-toed Blues produced offspring that were almost half Three-toed Blues."

"And the other half?"

"Something else," Mark said. "Everything else."

Benz shook his head in seeming disbelief.

"We took the Blues and culled out the sports—at least by phenotype—and transplanted the rest to this place. Now what do you see?"

Benz peered into the enclosure, inspecting the pool, the grass, the rocks, and the tree. "There seem to be frogs everywhere. All different colors. And I

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expect you're going to tell me that they're all different phenotypes, for all the different habitats, though I can only take your word for that."

"You expect correctly," Mark said. "It took them twenty generations to do it, but they filled every niche in the place with specialized breeds—right down to a dozen bug eaters that live under that flat rock in front, the only members of their breed that anyone has seen in this part of the forest for sixty-four years."

"And they're all offspring of the original Blues?"

"We've got the isotopes to prove it."

"And what about the trait drift in here?"

"The egg masses hatch out, the tadpoles swim in the pool, and when they mature, they sort out the phenotypes all by themselves—the rock hoppers head for the rocks, the peepers look for the trees, and the colored frogs find others of their kind and set up housekeeping."

"That's pretty amazing," Benz said. "I never imagined that it would be so simple and so complicated all at the same time. It seems so natural, and so alien."

"It takes some getting used to," Mark said.

"And you're sure that here too the same process operates on the higher animals of the planet?" Benz asked.

"We haven't been able to replicate the kind of generational data with them that we have with the frogs," Mark said. "And there's no historical record of anything like this among the higher creatures."

"I can understand that. But I'm sure you know that something is missing in your wife's reports," Benz said. He made the remark in such an offhand manner that Mark almost missed its significance. When he did, it was with a rush of panic that set his heart to pounding.

"Missing?"

"Of course," Benz said, still smiling, but shaking his head. "The mechanism, Professor Paradis. The mechanism. How do they do it? How does it work? And why in this strange universe should it develop in the first place?"

Mark felt his jaw drop, but neglected to draw it back into place.

"Why else do you think I traveled through space for four months and dragged myself to the steamy side of a volcano in the middle of an alien jungle. You have to tell me. And you have to explain why you're keeping it a secret."

The rain saved H'Ree from almost certain death.

The F'Tan infantry chased him out onto the Pelagi Road and then up it a long, long way. His lungs burned and he panted uncontrollably at the exertion of being chased. Their volleys of fire cut through the jungle on either side of him, but couldn't find their target. The pursuers drew closer and closer and their shots grew more accurate, until H'Ree was almost certain that the next one would be the last, when the skies broke open and the rain fell down.

Within an instant, he was swallowed up by a world of featureless grey, the sound of his ragged breath lost in the hissing roar of the downpour.

H'Ree kept his eyes down and followed the stones of the Pelagi Road as he pressed on, despite the drenching waters that streamed from the sky. There was no more shooting. The F'Tan seemed to have given up.

H'Ree kept going. He passed sodden lumps of yellow cloth along the edge of the forest and saw the blood washing onto the paving stones. He passed larger piles of debris—personal possessions that had been dropped or thrown in the haste of escape now growing soggy.

The rainfall continued undiminished. The great wide drops splattered painfully against H'Ree's face. The rain had long ago turned his tunic and shorts into dank ropes that dragged him downwards. Now it rippled the great ponds on the sides of the roadway where the curbs channeled the runoff. It splashed across the broad leaves and limbs of the

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rivertrees, collecting at the trunks and rushing down the channels that gave them their name. It turned to vapor and filled the space between the raindrops.

When H'Ree felt his legs start to weaken, he knew he had to break off his flight. He ducked into the forest and found shelter under a nakok tree that had engulfed the white stones of some ancient ruin.

He was not alone in his choice of refuge. A family of halflings, little round balls of soaked blue fur with frowns painted on them, sat in a line along one long tree limb.

As H'Ree settled onto a block of stone that was nearly dry, he thought about the halflings, wondering how wisdom found its way through their small brains. Some of them had the gift of speech, but few ever said anything that made sense, only imitations of true speech—insults, nonsense phrases, obscenities, curses. But was there a sharp line between the wise and the wild? Didn't it blur along the way between the truly wild and the truly wise?

All that set him apart was an agile tongue, three fingers and an opposable thumb on each hand, and the wits to put them all to good use.

Halflings were the unfinished business of the world, something nature had created for only one discernible purpose—to carry chamalian seed to places it would otherwise not go. But did they carry a knowledge that the wise foolishly dismissed and the wild secretly envied? Or were they simply nature's eternal buffoons?

He pulled off the drenched rags of his clothing and wrung the water from them. He opened his backpack and pulled out the poncho that he would have been wearing if the rains hadn't caught him otherwise occupied. As he pulled it over his head, he noticed the indignant look in the eyes of the halflings above him.

"If you don't like the rain, you have to do something about it," he said. "That's what being wise is all about." They ignored his comment, though one on the end flicked his tail at the Pilgrim.

"Or you can sit there and get wet for the next eighty-eighty-eight years, if that's what you want."

"Who's there?"

H'Ree froze at the sound of another voice, muffled by the patter of the rain. Was it more F'Tan? Or more refugees?

He waited silently in his dry spot, hopeful that the tall grass at the base of the nakok tree would hide him. Then a small figure appeared, one carrying a rainshield over his head, bifocals on his nose, and many rings of silver and gold on his fingers. His long pointed snout and broad pink ears identified him as a member of some rodent breed, but H'Ree couldn't see well enough to decide which one.

He certainly wasn't F'Tan and he didn't seem to be armed.

Nor was he alone. A train of eight smaller creatures, all of the same ratlike breed, strung out behind him in the forest.

H'Ree took a chance, gave in to curiosity, and called out: "Over here! But watch out. The jungle is full of soldiers."

He uttered a small oath, asking the spirit of Jobe to protect him from making a fatal error of judgment.

Mark Paradis felt his mouth go dry and his throat choke up.

"Surely you've discovered what makes your crazy world go 'round, Professor," Benz said. "I know you may not want to publish your theories until your data is solid, but you must have some idea of what you and your wife are chasing. Otherwise, how will you know when you've found it?"

Mark shook his head and stammered. There was no way he could begin to answer Benz's question without Alysa present. At the very least, she wouldn't talk to him for a long time. And at worst, there were any number of ways to end a life in the jungles of Chamal. Most of

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them left no trace of evidence to link them back to perpetrator. Alysa had told him more than once that if he tried to talk to Benz about the project without her around, she would kill him.

So he tried his best to divert Benz's ardor without being rude. "I'm sure we'll get to that at the proper time, Dr. Benz. But you'll have to be patient. Alysa wants to meet you before we start to get into the details of her work. And you should get settled in your quarters. If this rain would just let up, we could continue on."

The air went out of Benz's chest with a sigh and his shoulders sagged. "You're really trying to torture me, aren't you? Making me wait hours more after I've waited this long already."

Mark peered into the other man's eyes trying to determine just how serious he was.

Was he just having fun? Or was he really taking umbrage at the delay? There was no way to tell from his expression—much of it hidden behind the thick beard.

Benz set his teeth together in a pained smile, then sighed again. "Oh well, I guess I'll just have to wait until both you and Dr. Spenskaya are ready to let me in on the secret. But please, don't make me wait any longer than you have to."

"I promise, Dr. Benz," Mark said, feeling the relief of blood returning to his extremities as he realized that Benz was still in good humor. He ushered the scientist to the door. "Not a moment longer. In the meantime, let me show you the control center where we monitor the frogs seventeen hours a day, eight days a week...."

H'Ree discovered immediately that he was wrong about the newcomers. They were armed. Gunworks went click-clack and barrels poked out from beneath rain ponchos, setting H'Ree's fur arise.

He stood up to the danger, stretching on tiptoes and puffing up his chest, ready to pay the penalty for error. But no payment was demanded—and there was no error.

"Who goes there?" asked the leader, speaking in the sibilant tongue of the Gnar.

"A Pilgrim of the Way," H'Ree answered loudly. "Put down your guns and save your bullets for the F'tan. Aren't you a long way from home?"

"Home?" asked the head rat. "What home? Wat's Blood Roo is home to the Gnar no longer, thanks to the F'Tan."

"The Pelagi Road is crowded with the dispossessed today."

"You can say that again, Pilgrim," the rat said. He waved at his bearers, the gunworks clattered, and the tension dissipated. The short train gathered around the trunks of the nakok tree, placed their packs against the boles, and began stripping off their ponchos. A minute later, they had rigged them together into a rain awning large enough to shelter them all and the dank-smelling halflings besides.

The lead rat dug into a pouch at his belt and removed a clay pipe, some pipeweed, and a mechanical flamer. He puffed the pipe to life, then offered it to H'Ree.

"Thanks, traveler," he said as he drew carefully on the pipe. "So the F'Tan are moving south as well as west."

"That they are. I am Sessuan, chief clerk of the Gnar municipality of Fyntrakis. We carry with us the deed records of my office, to save them from destruction. Sad irony, that. The ownership of our land is no longer bound by scraps of paper, but by force of arms. We might as well use our burden to keep ourselves warm in a great fire."

"Then why do you carry it?" H'Ree asked, returning the pipe to Sessuan.

"Because one day the F'Tan will fall. And when that day comes, the Gnar will return and restore the ownership as we have recorded it. In the meantime, we seek refuge to the north."

"A bold plan," H'Ree said. "I am bound

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northward on my rounds, inspecting the state of the world as it changes from day to day."

"Good. Then we shall travel together," Sessuan said. He puffed on the pipe and looked up at the rain. "These are strange times we live in, Pilgrim. And they grow stranger every year since the Angels came to mortal ground."

"In what way?" H'Ree asked.

"The old order of things has been smashed," Sessuan said.

H'Ree laughed, and said: "But on this mortal ground, the old order of things is smashed all the time. Look around you at the bones of empires, kingdoms, nations, and city-states that have risen and fallen along the Pelagi Road."

"That was the old order I meant," the rodent replied. "Suddenly things are supposed to be permanent. How can that be?"

"Oh," H'Ree said meekly.

"This was inevitable, you know," Sessuan said. "The Angels have held things in check for too long. The pressures only built up. In the old days, the Bakamaru would have bumped and pushed at the Swince and the Tornoks, and the F'Tan would have pushed against the Gnar. A roo here, a hill there, until someone's seed goes sour and everyone scrambles to grab the leftovers. But then the Angels came and we all got religion. No more wars. No more fighting. Order and peace. It's just so unnatural."

H'Ree studied the tight cords of muscle in the rodent's neck, his bifocals, the ornate jewelry on his slender hands. He realized that in an important way Sessuan was very much like himself. They were both creatures of the new world, the age of the Angels. It gave them a gift of vision that their breed-fathers and tribe-mothers had never been allowed.

For once, they saw themselves as a whole race. They were no longer the parts and pieces of their broken heredity, but members of a greater totality. The pain of that moral knowledge was foundation of the Pilgrims of the Way, of course. But what had once been the private vision of a few chamalians was now commonly owned.

"Sometimes I wonder if wouldn't be better to be wild than wise," the rat clerk said, waving the stem of the pipe at the row of soggy halflings. "It's the same for them as for us—eat or be eaten. But they don't have to think about it. They get up every morning, do what comes naturally to them, and go to sleep at night. Us? Look at us? We get up in the morning and we have to think about what we're going to do. Every day is a struggle to solve impossible problems created by someone else. And you lie awake at night worrying about everything you've left undone. What's the point of being wise if all it brings you is misery?"

"What's the point indeed?" H'Ree asked boldly.

"You sound like you believe there is one," Sessuan hissed. "And like you know what it is."

"The only point to wisdom that I see is to ask difficult questions."

"Perhaps," Sessuan said. "Do you get answers?"

"Sometimes."

"And do they ease your way in the world?"

"Sometimes."

The rat looked at him a long time, then said: "I doubt it. I seriously doubt it."

H'Ree tried to hold his tongue, but he failed.

"I am tempted to offer proof, but I know better than that. A doubt that has its roots in honest skepticism can be satisfied with evidence and the tests of reason. But your doubt is rooted in something much deeper. It is born of the dislocations of both the moment and the past eightyear.

"I have seen this before in the eyes of the wise. It is a wild doubt, not a wise one. It can not be satisfied by any wise words. And it gives rise in turn to unwise desires and appetites—a taste for

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idolatry, superstitious lies, and all the false comforts of selfishness that the soul of wisdom can create for itself."

Sessuan shrugged. "The modern age seems to be a particularly cruel one," he said.

"That it is. Even when you are equipped with what little true wisdom that our race has accumulated in the years since it climbed up out of the swamp. Even when you are equipped with the true wisdom of the Angels—or what bits and pieces of it they allow into currency."

"Now there you speak truth," the rat said with enthusiasm. "Take this idea of democracy. They spread it around and teach it to the young. But it is a truly alien concept that only a purebred race like the Angels could have created."

"The Pilgrims of the Way saw the idea at its core long ago," H'Ree said. "All creatures that carry the Seed of God are fundamentally equal in a way that transcends the material world. The ability to know and know that we know sets us apart from nature, makes us wise instead of wild. And that is one of those facts that has no gradient, no fungibility, no divisibility. It is equally so for rat and cat, leaf-eater and hunter, flyers and diggers, from the deserts to the jungle to the ocean to the great heights of Kwikorak to the bottom of the Arkarian basin."

"But to make it the basis of political power?" the rat hissed. "Are the Angels trying to destroy this world?"

"No, I believe they they are not," H'Ree said. "But there has to be more to the Angels' wisdom than democracy all by itself. If they use it as they say they do, there has to be some other wisdom mixed in."

"That may be," Sessuans said. "But by itself, democracy has brought only ruin—at least to this small piece of Chamal. Just look at the Bakamaru. In the old world, the weasels who ran the place when I was a youngling would have gone back to the bush by now and the place would have been taken over by the hounds. But after the Angels came to ground up on Purple Frog Mountain, they got democracy over there. Weasels and hounds, monkeys and diggers, tree woofers and swamp swimmers all got together and made themselves a nation out of a two-rock kingdom. They got their parties and their lobbies and their campaigns and they got to scratching each other's backs and doing what the mobs of half-wise wiselings wanted. And the only way to pay for it was to grab someone else's land. Without democracy, they never could have done that. Never would have started the F'Tan on their way through Wat's Blood Roo."

"You're right about that," H'Ree said. "There's something more to their wisdom than what they've given us. And we deserve the whole thing—or nothing at all."

"Nothing at all would be my choice," Sessuan said. "We were better off without so much wisdom."

The rodent relit his pipe, offered it to H'Ree, then tended to his party. H'Ree realized with a shock that they were all female. The shock came from not noticing earlier. A moment later, he received a greater shock when Sessuan took advantage of the impromptu shelter to take advantage of them. H'Ree turned his back on them and puffed on the pipe while he watched the rain come down.

Sessuan had worked his way through half his pack when the brush beyond the many trunks of the nakok tree exploded in noise and motion.

It was the tree cat.

She burst through the leaves into the wide clearing beneath the nakok's broad network of limbs and branches, then froze instantly. Her head swiveled in brief intervals as she scanned her surroundings. When her eyes met H'Ree's, she relaxed.

"Once again we meet on the Pelagi Road, Pilgrim," she said.

The rats went scrambling for their

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weapons, but H'Ree put up a hand and Sessuan ordered them to hold their fire.

"I would dally with you longer, but I must move on," the cat said. "And I would recommend that you do the same as well. Nothing spoils an appetite as much as holes in the menu. And the F'Tan follow quickly on my heels, ready to make holes in all of you."

"I believe I am in your debt," H'Ree said.

"I don't think you would want to be in that position, Pilgrim, but I take account of it anyway. This is twice that I have foregone a repast with you out of haste. Perhaps it will become a habit."

"I hope not," H'Ree said. But his words were lost in another crash of vegetation as the tree cat bounded off again.

The rain lessened slightly, the steady drum of water on leaves and ground giving way to more distant sounds, including a volley of crackling gunfire not far distant.

"I believe she was correct," Sessuan said as he rearranged his clothing for comfort.

"We should be as hasty in our departure as she was," H'Ree said. "I don't think the F'Tan waited on the rains nearly as long as we have."

And with that, H'Ree pulled up the hood on his poncho and strode out onto the Pelagi Road, trying to ignore the torrent that still fell from the sky. He had gone quite a distance before he realized he still had Sessuan's pipe.

Mark Paradis had never been so happy in his life to see the rain end.

The clouds still hung low and water continued to drip off trees and leaves and eaves, but the downpour ended almost as abruptly as it began. And with it came his freedom.

Or nearly so.

He hustled Benz out of the frog farm and back up the hill to the house as quickly as he could without upsetting the man. His relief was complete only when Benz was safely installed in his cabin.

"You can come out now," Mark said when he returned to the main house. "He's unpacking and you won't have to talk to him."

Alysa emerged cautiously from her office and looked around.

"Don't you believe me?" Mark asked.

"Why should I?" she replied. "Where were you two?"

"Down at the farm looking at frogs."

"What did you tell him?"

"Nothing that he didn't already know."

"And what did he say?"

Mark took a deep breath, then let it out. "He wants to know the secret. He wants to know how chamalian genetics work and how they evolved. He's sure we've figured it out and he wants us to share it with him."

Mark watched his wife's expression carefully, trying to gauge her response. But it wasn't worth the effort. When she wanted to be, she was too icy, too impenetrable, too hard to fathom.

"I was afraid of something like this. He's way ahead of us. Why did this have to happen now? Why couldn't they just be patient and wait for us?"

"We knew it was coming sooner or later," Mark said.

She turned on him so fast that his head snapped back. "If you didn't insist on stirring things up with your textwars, it would have been a lot later."

Mark held his tongue, refusing again to be drawn into that old battle. He had long ago built a strong defense on that issue, but in order to be effective, he couldn't expose himself. Instead he tried to soothe her anger.

"Come on, Alysa, what can he do? Cut off our supply of grad students? We can work this place with the Toroks and the other locals."

"What can he do?" she asked, her white skin turning red with anger. "He can replace us, that's what. Cut off our supply of grad students? He can cut us off, send us home, and ship out a new team to take over our work—my work.

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You are so naive, Mark. Don't you realize what we're gambling with? And you want to go shooting off your mouth without me around to watch you."

"I didn't say anything," Mark protested. "And you're the one hiding in the office, not me."

She set her lips together and scowled at him, but didn't say another word. She didn't need to. He already knew what she would say, and she already knew what he would say in return. They saved a lot of time during their arguments these days, thanks to that, and they ended up with fewer bruised feelings when it was over.

"All right," Mark said at last. "What are we going to tell him? We've only got a couple of hours to prepare, and then we're going to have to eat dinner with him. Are you ready for that?"

She walked out onto the porch where the sun was beginning to break through the steamy sky and spill golden light onto the woodwork, then she walked back.

"All right, darling, we have to figure out what we're going to do."

The end of the rain and the approach of the F'Tan brought the refugees out of the jungle in force.

They filled the broad Pelagi Road as it climbed to higher and higher ground, lumps and clumps of every breed that wisdom had touched between here and the F'tan lands—diggers and climbers, mudrats and tree-apes, bushcats and froggers. There were even a few breeds that H'Ree had never seen before and knew only by reputation..

He pushed past them as quickly as he could, the urgency of his mission amplified by the obvious suffering all around him. Families and tribes struggled with packs of belongings, wailing young, scampering litters, and obstinate draft animals.

"I'm hungry," moaned one beast of burden that had been blessed with speech, but not the wisdom to know when to remain silent. "I'm tired. I want to go home."

The protests brought a snap of the whip from the mudrat that led the beast, a pile of household goods lashed to its back, through the thickening mob.

As H'Ree recalled the topography of this part of the rain forest, the Pelagi Road made a broad sweep around to the north as it climbed into the highlands at the base of the Angels' volcano. And its arc encompassed much of the wet lowlands to east, towards the F'Tan.

The result was that rather than being pursued up the road from behind, the refugees were being flushed out of the jungle and onto its stony pavement all along its length. That made the going all that much more difficult for H'Ree. He could never get ahead of the crowds because they kept pouring out of the brush however far he went.

And it wasn't long before the panic set in.

Someone thought they heard something. Or someone did hear something. And the word spread that the F'Tan were among them. The screams rippled up the road and the wise became wild in their effort to escape the unseen danger.

H'Ree was almost trampled underfoot by one such frenzy.

He resolved to do something about it.

"You know, the Angels are up ahead," he told one wrinkled, gray climber patriarch as he herded a passel of half-grown young along. "The F'Tan are afraid of the Angels. They fear their power and their just retribution."

The patriarch nodded and repeated H'Ree's admonitions to his brood. "You hear what the pilgrim said. The Angels will watch over us."

The young climbers looked at H'Ree dubiously and huddled closer together.

He moved on and repeated his words to the next family, and the next. Before long, he found that the words were beginning to outpace him. "Are those the Angels up ahead?" one female bushcat asked.

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"I hear they're coming to stop the F'Tan," said her traveling companion.

H'Ree felt a brief moment of pride, but he was unable to savor it. He knew it for the lie it was. He had no reason to believe the Angels would help them. Indeed, he had never spoken to the creatures himself. The Pilgrims of the Way had strict rules about interacting with the messengers from the heavens, and lowly dogs like H'Ree were not included among the select few to whom they applied.

An instant later, what little pride he was allowed also fled away.

The crackle of gunfire was unmistakable, undeniable, and all too close. The screams of terror and pain were clearly different in tone from those of artificial fear. And they were followed by another volley of fire, this one much closer.

H'Ree pressed on with renewed vigor, but found the rest of the mob in the road did the same, swelling together and pushing him forward in spite of himself.

Boom! Boom! Boom!

A round of explosions ripped through the woods immediately to his right. Fire and smoke poured into the roadway and bodies thudded onto the wet ground.

H'Ree was running now, his breath raw in his throat, his livers tight with fear. He took no notice of those around him except as obstacles to escape.

Boom! Boom! Boom!

Another round of explosions tore into the horde, farther up the road, forcing them away from the jungle on one side and into its embrace on the other. The F'Tan were no fools. They had to push the refugees off the road if they wanted to complete their plans. H'Ree knew that the land was not enough for them. They wanted the breeds that had owned it as well—either dead to prevent their testimony to the Angels or enslaved to enrich the new owners.

Suddenly a small metal canister fell onto the road in front of him and bounced on the pavement. A dozen more just like it rattled and clanked against paving stones or thudded against fleeing refugees. Where had they come from? The trees overhead? The thick bush along the sides of the Pelagi Road? And what were they?

The answer to that question leaped into H'Ree's throat.

"Grenades!" he yelled as the knowledge of what they must be seized his attention. He stooped and grabbed the one at his feet. "Quick—throw them back into the jungle!"

All around him the others stopped, thought for the briefest of moments, then grabbed at the deadly metal bombs and began lobbing them away from unprotected flesh and bone.

Boom! Boom! Boom!

This time the explosions were muffled by the bush and were accompanied by more distant screams of pain and anguish.

Boom!

Something bit at H'Ree's thigh as he realized with sudden despair that one of the grenades had been overlooked or thrown short. His leg felt numb for a moment, then burned with pain. He looked down and saw blood welling up through his fur.

The sight made him suddenly queasy, and he looked away. But the pain sang out with every step he took. He had to give the injury some attention, whether he could stand it or not.

On closer inspection, he saw that a splinter the size of two fingers had imbedded itself in his flesh. He couldn't walk as long as it remained there. He swallowed hard, then reached down and grabbed it hard.

The pain bit at him again as he yanked it out. The ache that followed was almost a relief. He pressed against the wound, trying to slow the flow of blood. Someone stopped beside him, an ape of some sort, and tore a piece from the bottom of his tunic, then tied it around H'Ree's thigh. It wasn't much, but it was enough.

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The explosions stopped and the gunfire subsided as he continued on up the road. But the refugees continued to spill out of the woods, no longer coming in drips and drabs, but forming a steady flow, all of it moving northwards, ever closer to the camp of the Angels.

H'Ree steeled himself against the ache and pressed on.

In the end, Mark and Alysa couldn't agree on what to do.

"Why won't you be reasonable?" she asked.

"Why won't you be patient?" he countered.

They ran out of time. The night fell with the characteristic suddenness of the tropics. Dinner followed soon after, with all five of the grad students dressed in what passed for formal outfits to entertain the visiting scientist.

It wasn't long before Mark realized he could put off the inevitable for much of the evening this way. He and Alysa both let the students occupy Benz's time and attention while they could.

And when the meal was over, Benz produced a surprise of his own that prolonged the evening's armistice—a bottle of brandy. "I knew it was something you wouldn't be able to find around here," he said. "And I realized that if I were in your position, I would want someone to bring me something like this."

It took them some hours to finish off the brandy. Benz regaled the students with tales of university politics while Mark and Alysa remained quiet in the background.

But eventually the grad students had to leave. Unlike Benz, they had work schedules to keep. Mark felt his guts tighten as he watched the last student walk down the steps to the base of the tree and head off into the darkness.

Then they got down to business.

"Dr. Spenskaya, I find your work absolutely fascinating. The genetic analysis is remarkable. Your labs are ingenious. But Professor Paradis, your application of these findings to the higher life forms on this planet has upset a lot of people."

"That's putting it mildly," Mark said. He tried to get a reading of Benz from his manner, but the man was so openly affable that it was hard to ferret out any nuance or spin.

"That's what I find surprising and confusing," Benz said. "Why? What do you have to say that seems to upset so many people?"

Mark sighed—and tried to avoid the steely gaze of his wife, who was showing remarkable restraint by letting him continue the conversation this far.

"Some people just want to believe what is simple or fashionable. That's not possible when you confront them with something complex and different."

"And your analysis is both?"

"Yes, but no more than the subject matter," Mark said.

"Then explain."

"The human race has a big problem here on Chamal. Up until the day we arrived in orbit here, the intelligent creatures of the planet were engaged in steady and sophisticated political violence and had been for some centuries."

"Political violence? You mean war?"

"In all its variations," Mark said. "Constant and unrelenting. Big and little. Broad and narrow. Hot and cold. With ever-greater technology to be used against one another. Long-range missiles were in use and nuclear weapons were almost at hand."

"And that all changed when the first ship from Earth arrived."

"Yes. Chamalians were suspicious of us at first. Pathologically so. Despite their perverse genetics, they have a highly developed moral sense—in many ways they see themselves as a depraved race, cursed by nature. They were afraid we had come to destroy them for their sins. After a short time, however, they decided that the only way to prevent that from happening was to stop the fighting all over the world. So they did. Overnight."

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"I see," Benz said, nodding in appreciation. "And how is this a problem for the human race?"

"We still have to decide if they are right. Are they indeed too cursed by nature to be allowed to live?"

"Oh—that problem," Benz said with a sigh of resignation.

"Yes. That problem. On one side you have people who believe that they are. They want to see the planet sterilized. They believe that the violence is wired into chamalian genes—just like it's wired into human genes. They argue that aggression and territoriality are integral parts of intelligence, and that chamalians are too primitive to overcome their genetic heritage. They believe that war between humans and chamalians is inevitable, once Chamal develops the technology they need to fight us."

"You have to admit they have a persuasive argument," Benz said.

"I don't have to admit any such thing," Mark said offhandedly. "Their argument is nothing but warmed-over Social Darwinism and vulgar sociobiology—the default paradigms of social analysis for the uneducated members of a technologically and scientifically advanced culture."

Benz looked him in the eye noncommittally. Mark wondered, a moment late, which side the physicist was on. Did he agree with the hawks? Had he come to put an end to more than just his work?

Alysa continued to glare at him from across the table, but she didn't make any move to stop him. Maybe she thought it would be better if he got this out of his system.

"Default paradigms of social analysis?" Benz asked.

"It's what people believe without knowing they believe it. Because they don't know they believe it, they think it's just the way things naturally are. And that makes it hard to talk to them about things being different."

"I see."

"Social Darwinism is a misunderstanding of evolution. It explains a competitive social structure like free-market capitalism or cutthroat academic bureaucracies much better than it explains social change or human nature. And by vulgar sociobiology, I mean the popular idea that genes determine intelligent behavior. It's speculative science, not experimental science. In more than two centuries, no one has ever identified a gene that can be linked to a specific human social behavior—but there is no end to the speculation about how such a gene could control that behavior."

"And without experiments, it can't be disproved, making it a durable idea," Benz said. "I understand the problem there."

"There is no gene for *Hamlet*. There is no gene for the *Mona Lisa*. And there is no gene for racism or war. These are entirely inventions of the mind itself. They are acts of will. They are the creations of history and the historical process, not the crude conditioning of preprogrammed genetic instructions.

"Now look at the chamalians. You have a race of creatures that can interbreed and swap traits between what on Earth would be different species. The whole idea of species no longer applies here. Traits are inherited and dispersed throughout the gene pool. And among these are the whole suite of traits associated with self-conscious intelligence—language, tool use, social and cultural structures. They float freely from phenotype to phenotype, just like the colors of the frogs."

Benz smiled again and said: "A race that is barely a step away from its primitive roots. A race where aggression and territoriality and the struggle for dominance and survival are only a generation away."

"Exactly," Mark said.

"And you don't agree with that?"

"Not at the root. Not about the source of the aggression and the territoriality and the struggle for dominance. Not

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about the source. It's not natural selection. And it certainly isn't determined by our genes."

"Then what is the source?"

"Self-consciousness itself. The fact that self-awareness takes a creature a half step out of nature and forces it to make conscious decisions about its own life. That's where the aggression and the territoriality come from. That's where the hatred and the desire for dominance and destruction come from. These are not genetically-driven instincts. Animals don't act like that, and genes don't have that kind of power. That comes from the crack in nature that consciousness creates. These are uniquely self-conscious, uniquely human afflictions. They are some of the ways we attempt to answer the challenge of existence—failed attempts to be sure, but attempts nevertheless."

"And you have an answer that isn't a failure, don't you?"

"Of course," Mark said. "Reason. Simple and clear. The ability of the self-conscious mind to perceive and test the truth and arrive at a rational conclusion. The only thing that can quench the irrational passions, overcome the irrational doubts, and cast light into the darkness of the soul."

Benz laughed heartily. "Reason. Of course. What else could it be?"

Mark felt a rosy glow of satisfaction wash over him. For a moment, it seemed as if he had won over the physicist to his point of view. And then the moment passed.

"But isn't there a danger, Professor Paradis, in a position that makes it sound like you are the only one who possess reason while those who disagree with you do not? Don't you run the risk of ignoring what could be a reasonable counter-argument?"

Suddenly Mark couldn't breathe. Benz had misconstrued his argument and was now turning the distortion against him. Alysa shook her head at him, narrowing her eyes and looking fierce.

He felt pinned in place by the unexpected question, disguised as reason itself.

H'Ree's leg burned with the pain of his wound. The blood stank where it had dried on the bandage. When night fell, he found that he could not continue walking—he kept stumbling in the darkness and each time he fell the pain shot through him like a blast of flame.

He could not remain on the Pelagi Road either, he quickly learned. The F'Tan were falling on the refugees and carrying them away—a child here, an oldling there, a whole family farther on down the road. So he found shelter in a stone ruin that smelled like the day home of a nightstalker. A brief inspection with his electric lamp revealed a pile of well-gnawed bones in one corner.

He set his pack-clock to wake him before dawn so he could leave before the permanent tenant returned, then laid down to sleep. He was awoken in the middle of the night, however, by the sound of shouting and singing.

He pulled himself up to threshold of the ruin where he could look out into a large grove surrounded by high, limbless trees and illuminated by torches on high poles. In the center of the grove were dozens of corpulent figures, pressing shoulder to shoulder before a tall pile of wood—F'Tan soldiers. Atop the pile were what appeared to be sacks of something.

Then H'Ree realized they were living creatures, bound at the hands and feet. He watched in horror as the F'Tan set the pile of wood on fire. The sound of the screams echoed through the jungle for much too long.

As he watched, the F'Tan began to chant, then sing again. It was a low, discordant tune that hardened his gut. Then they began to dance in a slow circle around the pyre. This continued for a long time before a new party of F'Tan arrived. He was afraid they had brought

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more victims for the fire, but instead they bore a large golden statue. The statue caught the light of the fire from every direction and glowed in the dark depth of the forest. H'Ree looked at it for along time before he realized that the it was the figure of a ram. He wondered how it had come into the hands of the porcine F'Tan.

The F'Tan fell down on their knees before it, making guttural animal sounds unsuited to creatures that possessed wisdom. For the next hour or so, he watched in rapt fascination as they worked themselves into a feverish frenzy, rising and falling as a group, with more chanting, singing, and making of ghastly sounds.

"Quite a display, but if you watch it much longer, you will find yourself an unwilling participant."

The sudden soft voice in his ear set every hair on H'Ree's body on stiff end. He didn't move, but he cast a glance in its direction. He was not surprised to see the face of the cat illuminated by the F'Tan torches.

"They are afflicted with darkened hearts," H'Ree said. "They find wisdom so terrible a burden that they seek to lose it in the mindless worship of idols. It is sad that wisdom is wasted so by the wise."

"Sad indeed," said the cat. "But don't compound the sadness. There are skirmishers beating the bush looking for stragglers like you. We must move on. Your wound smells ripe—can you walk?"

"I haven't tried for a while. But I've worked to keep the leg from stiffening up."

"How did it happen?"

He told her the story of what happened on the road.

"A hazardous thing for you to do," the cat said.

"Is this meant to be new information to me?" H'Ree asked as he rose carefully, put some weight on his injured leg, and tried hard to keep from crying out. Despite his exercises, the leg had become hard and painful. "It will have to do, I suppose."

"You can lean on me," she said.

H'Ree looked sideways at the creature, measuring his doubts against his needs. "Is that a safe thing to do?"

"I have decided that you are a creature of reason—unlike those animals out there. As such, it would be a sin to transform you into simple supper," the cat said. "And I get the sense that somehow you are always good. This is something I don't think I quite understand."

"Not always," H'Ree said. "Sometimes I make mistakes."

"I am certain that your worst mistakes are better than the best most of us can do. Besides, I have already filled myself with F'Tan bacon."

H'Ree put his arm on the cat's shoulder and limped along through the dark. She guided him along, helping him avoid disaster among the roots and stones that covered the ground.

"If it isn't an offense," H'Ree said, "may I ask your name?"

"No offense," the cat said. "I am called Chierk An."

"And I am H'Ree t'Fugguls."

"Creatures who know each other's name should not be afraid of being eaten," Chierk An said, then she began to purr.

Mark heard the peeping of frogs and watched through the window at a sudden tropical sunrise. They had talked all through the brief chamalian night. If only they had stopped sooner ...

"You'll have to excuse me," Alysa said suddenly, as she rose from her chair and headed for the door. "I feel ill."

"Oh dear. Is there something we can do for you?" Benz asked, seizing the initiative from a befuddled Mark Paradis and almost leaping to his feet.

"No, it will pass in a minute. I'll be right back."

Mark stood clumsily, but found himself with no direction to take. And he

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found himself wondering if Benz hadn't simply misconstrued his argument, but instead had set a subtle trap for him.

His doubts were dispelled somewhat when Benz quickly changed the subject. "You know, I am still dying to know the secret."

"The secret?" Mark stammered, pretending ignorance and feigning an absent-mindedness that he hoped would fool Benz.

"Yes, the underlying reason for all this," he said, waving a hand at the world beyond the verandah. He crossed the room and stepped outside, taking a deep breath of the strange perfume of the alien world.

"How did it happen?" Benz asked. "How did this race of creatures evolve in the first place? What combination of serendipity and necessity brought them into being? Surely you must have considered the question. Surely you must have an answer."

"Nature is fiendishly clever," Mark said, as he joined him. His mind still raced and his defenses were still up, but the question gave him something else to think about. "It doesn't do just a single thing and be done with it. It is manifold in its complexity."

"More abstractions from the reasonable man?" Benz asked sharply.

"Just an observation that lays the groundwork for an answer. Come here," he said, leading Benz to the porch railing. "Look out there to the east in the distance where the water catches the sun."

He pointed down into the rainforest where it spread out for many kilometers around the base of the volcano. A dozen or more perfectly round ponds and lakes splashed the gold and red rays of Chamal's K-type sun across the morning. "See the ones that are just arcs and sectors? They're called 'roos.' Those and the lakes are all ancient astroblemes—impact craters. The round lakes are small high-energy craters and the roos are older structures where the crater floors have rebounded. The planet is covered with them. No plate tectonics to wipe them away—mainly because the crust is too deep.

"They say that consciousness is formed by the material conditions of its existence. Well, life is formed just the same way. Chamalian nature was forged in those ponds and pools and hundreds more that lie beneath the triple-canopy forests. Each one separated by its neighbors by a low but passable threshold. Each one is a breeding ground for a different variety of life. It doesn't take a whole lot of imagination to see how those conditions would favor a lifeform that could acquire all the traits of a new environment, incorporate them within itself, and then save them for dispersal over future generations. And that's what I mean by nature being fiendishly clever. There's not just one thing going on here, but several. They don't just share traits, but they redistribute them as well.

"And in that way they are truly alien to our way of thinking. The rigid categories of thought that we impose on the world do not function here. Everything is in flux. Nature behaves more like spirit, like the imagination, than it does like matter.

"We evolved on a world full of islands—great ones and small ones, but islands nevertheless. There was always a world inside and a world outside, beyond the sea, separate and independent. There is no ocean here on Chamal. There is no outside. Everything is an inside.

"Culturally it's just the same. There could never be an England here, with its tidy, clockwork sense of the world, everything discrete and self-contained. Or a Japan, with its complex rituals to maintain distance and integrity. Or even an America, with its sense of a special role in the world. It's like the continental interior—dark and mystical, with a struggle for dominance and submission, full of superstition and fear, but with

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brilliant flashes of insight and creativity from some hidden wellsprings of life. Feuds and incest—there are actually quite a few chamalian societies where inbreeding within the family is encouraged—vendettas and vengeance are the rule in this land. With only a few small sparks of enlightenment, a few small seeds of reason, spread across it. Because if every wise chamalian is only a generation away from aggression and territoriality and the struggle for dominance and survival, then every wild chamalian is just as close to science, art, philosophy, and knowledge."

"That's quite fascinating, Professor Paradis, but I'm afraid it misses the point."

"The point? What point?"

"The point of my question. What is the mechanism? How do the genes do what they do? That's what I want to know. Oh, to be sure, now I understand why they do what they do, and for that I am grateful. But you've left out the most important part."

Mark felt his throat close up. Once again, Benz had unmanned him.

He didn't know what to say. He didn't even know what to think. He had prepared hard for this moment, had marshalled his thoughts carefully for days. But he hadn't considered what response Benz would make. He hadn't even considered the possibility that Benz would make a response. And now he was struck dumb.

It was Alysa, not Mark, who answered: "That's because we don't know."

His wife stood in the doorway to the house. Her cold eyes had softened, perhaps with the acceptance and admission of the truth.

Benz sighed, and Mark turned to see his face sag. "You're not teasing me, are you?"

"Not at all," Alysa said as she joined them, wrapping her arm around Mark's. "We have tried for years to find the answer to your question, but we have not had any success."

"But you must have some idea of how chamalian genetics work."

"Ideas? We have plenty of ideas. Far too many ideas. We don't have nearly enough facts. We don't even have a genome for these creatures."

"You don't? That seems odd. I thought you had mapped their genes the first year you were here."

"A map we have. But of what, we don't know. The human genome was easy to fill in. You had researchers all over the globe working on little pieces and doctors working on different diseases. You already had the pieces, you just didn't know where they went. We don't even know what the pieces are. Here we have me, my grad students, the institute in Suridash, and a very, very small contingent of chamalians who have learned what we have been able to teach them. Our results are disappointingly small."

"And what is your idea? Do you have some vision of what a complete genome would show?"

"I know many things about the chamalian genome. It works to conserve survival traits, not the creatures that carry them. When they reproduce, when the zygotes are formed, something parses out those traits in whatever combination it sees fit. It uses a counting scheme: We've even derived some of the rules. There aren't terribly many—a half dozen, maybe eight. But it keeps careful track of things from one generation to the next. It keeps careful count of how many traits are activated and how many are repressed. And the result is that a population of intelligent tree-cats can dissolve in three generations into a dozen different kinds of wild little rodents, lepoids, and proto-primates—who then disperse into the environment and six generations later reconstitute into a population of intelligent apes."

"Yet you have no idea how the genes do this."

"A guess. It's probably a lot like telomeres."

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"Telomeres?"

"In the middle of the twentieth century, biologists discovered that human cells could reproduce themselves only fifty times before they reached the end of their lives and died. But thirty years passed before they discovered why. The genes had long chains at the end called telomeres. Every time a cell reproduced itself, the telomeres would grow shorter. When they were gone, the cell died. That's why we take telomerase to prolong our lives, to repair the telomeres in our genes."

"But you haven't found your telomeres?"

"You obviously have no idea how much genetic information a chamalian carries around."

"It was not one of the facts that I dwelled upon," Benz admitted.

"The human genome is a code three billion letters long, but ninety-seven percent of it carries no useful information. The other three percent make up a hundred thousand genes. The chamalian genome packs the information with much higher density—more than twelve percent of the genetic material carries useful information."

Benz whistled.

"I hope dearly to find my telomeres," Alysa said. "I know that I will recognize them when I see them. I know what they do. Their counting games will be impossible to hide. But until I do, we have this problem."

"Problem?"

"Until we find and identify the way the genes do their counting, we have nothing but speculation. We are reduced to imaginary genes and our imaginary ideas about how they work."

"Vulgar sociobiology," Mark said.

"Sociobiology," Benz repeated.

"My husband is a very wise man and I agree with much of what he has said. But we are divided on this point. He is adamant in his opinion of so-called sociobiology—and he is probably right. But until I find the mechanism that drives chamalian genetics, I am left with nothing but speculation about imaginary genes."

Benz looked from Mark to Alysa and back several times without speaking. It had been a long night, even for Chamal, Mark realized, and it was taking a minute for the understanding to sink in, but sink in it did.

"I am terribly sorry for both of you," he said at last.

"I am sorry that we have failed to give you an answer to your question. We were afraid to admit that we didn't have one. Afraid of what failure might mean. Regarding the audit, I mean."

"The audit? Oh dear, this isn't about the audit. Not at all. As I told your husband, I have an irrepressible curiosity on this subject. It is entirely personal and has nothing to do with the audit."

Mark couldn't believe what he was hearing. Alysa looked stunned as well. Were all their fears a pointless exercise? Had they been the victim of their own irrational suspicions?

"You mean we haven't failed?" Mark asked weakly.

"Failed? Because you haven't found what you need to answer my question? Being unfinished is not failure."

"This sounds too good to be true," Alysa said. "If that was not the problem, then why are you auditing us in the first place?"

"I thought you knew that," Benz said. "The authorities back on Earth are growing concerned about what Professor Paradis is teaching the chamalians. There's some talk that it smacks of subversion and revolution. And there's some talk that it should. I'm sure they must be exaggerating, aren't they, Professor?"

Mark swallowed hard as he felt all the blood drain from his face.

The morning sun quickly warmed the stones of the Pelagi Road as H'Ree limped along, leaning on a walking stick the cat had left him, making poor time on his desperate flight to the north. The

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fear that the F'Tan might catch up with them again grew stronger with every stride.

Then the word came down from ahead, moving faster by mouth than feet could ever carry it.

"The F'Tan have cut the road to the north! There's no escape!"

H'Ree felt his livers tighten and pushed on even harder. Only now he was having a worse time of it than before, because now he was pushing against the crowd. And it was a panic-stricken crowd that threatened at any moment to become a stampeding herd.

His own fear nearly took hold of him, sending him in a wild panic back to the south. He fought it, forcing it to retreat before his wisdom. Because he was seized with an idea. If the F'Tan were going to challenge the Angels, then let them do it where they could be seen. And with all the refugees as witnesses to their atrocities.

He shook his head, then grabbed a pack animal pulling a wagon filled with household goods to one side. He silenced its master and climbed atop the pile of goods, wincing at the strain that it put on his injured thigh.

"Stop!" he called out. "Stop now before it's too late."

A handful of frightened creatures slowed in their flight, bewildered at the spectacle of an old pilgrim making noise.

"Fear not! The Angels are close at hand!" H'Ree said.

While that failed to get the attention of those who had slowed, H'Ree poked his walking stick among the legs of those closest to him. They tumbled to the ground, and their inertia caused more refugees to slow.

"They are just up the road from here. The camp of the Angels is a haven. We will be safe there. The Angels will see that no harm will come to us."

The murmuring of voices grew louder. "The Angels," they said. "The Angels will protect us."

The growing clot of much-suffering creatures now spread out to block the road completely, and H'Ree felt uncomfortably conscious of it.

"Where are the Angels?" one wise young rodent called from his right.

"Up ahead, three leagues, no more. I know the way. Spread the word!"

That was all it took. Now a countermessage traveled up the Pelagi Road, slowing the flight of the refugees, opening the way for H'Ree. And to improve things slightly, he was riding in the wagon he had mounted and no longer had to limp.

Now if only his words were true. If only the Angels could protect them.

For he had no idea whether they could or not. Or whether they would even if they could.

Worse yet, they might consider a horde of chamalians streaming through their gates as a dangerous threat and eliminate all of them before they could explain themselves.

Alysa wouldn't let the conversation proceed beyond Benz's last remark. Mark didn't know what to say, in any case. He didn't consider that part of his activities on Chamal as falling under the research grant, and therefore hadn't expected it to be a problem for the grant audit. And since he hadn't given it any thought, he was caught completely off guard.

His wife knew this. She had done it to him herself so many times that it was inevitable. And so she intervened decisively.

"That is something we will have to discuss after breakfast," she said. "After we've all had some rest. Don't let the sunrise fool you, Dr. Benz. The clocks on Chamal run faster than we do. Can you find your quarters by yourself?"

And so they parted. When Mark and Alysa were safe behind their bedroom door, he tried to apologize. "Don't start, Mark," his wife said. "Neither of us saw it coming. We'll talk about it in the morn-

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ing—*before* breakfast. At least you can be prepared now."

They never had the chance.

The next thing Mark knew, he was being was roused from a restless sleep by a loud knocking on his door. It was one of the grad students. "Professor, I think you'd better come take a look at this," she said.

He and Alysa roused themselves quickly, pulled on some clothes, stuck their feet into their boots without tying them, and hurried onto the verandah. Mark caught his breath when he saw what had upset the grad student.

The whole motley menagerie of intelligent chamalians that inhabited this part of the rainforest seemed to have come calling on them. There were hundreds in the yard, with more behind them, streaming up the hill from the southeast.

"My goodness, what's the occasion?" Benz said as he joined them.

"I'm not sure," Mark said. "But it doesn't look good."

In the middle of the yard, the mob parted to allow a large wagon full of furniture and clothing to lumber along, a scruffy, bewhiskered hound atop it dressed in the burgundy outfit of a Pilgrim of the Way.

The dog stopped the cart, clambered down, and hurried on ahead, limping as he worked his way to the head of the crowd. Alysa and Mark hurried down the steps to meet the creature, Benz following right behind.

The chamalian was barking and shouting, but without a translation link set up with the camp AI, there was no way to make out what his words meant.

"What is it?" Benz asked. "What's he saying?"

"I don't know for sure," Mark said. "But it sounds like: 'Timmy's in the well.'"

It was all H'Ree could do just to stand there and face the purebred beings from the stars. While chamalians possessed powerful technologies of their own—space travel, electronic brains, radio, and death rays—the Angels owned machineries that made them seem as simple as forks and knives. And their moral power, as purebred creatures from a world that had fallen from grace, then recovered itself, was even greater.

Someone—a golden-haired ape with delicate hands—brought him an oddly shaped headset and clipped it into place at the collar of his tunic. "They speak to you through that," the ape said.

A voice sounded in his ear: "Welcome to Camp Paradis. Can we do anything to help you?"

Every nerve in H'Ree's body was alive. He hadn't felt like this since the last time his brain had grown. Each movement, each sound, each color, each creature of the eighty-eighty-eights around him was bright and distinct and filled with energy.

He saw four Angels. Judging by their manners, they were a male who seemed to be in charge, a female with only two breasts, a younger servant of those two, and an older male who commanded the deference of the other three. The refugees continued to stream into the compound behind him, their rumbling roar growing louder and louder.

"We seek sanctuary," H'Ree said. He chose words that had a specific meaning to him and the Pilgrims of the Way. It was a request that the Pilgrims had always pledged to obey themselves. It was a request for neutral peaceful ground where differences of seed and breed were set aside, where the lamb could lie down with lion and rise again. He only hoped the Angels' machine would translate it correctly.

"Sanctuary?" asked the male Angel. "From what?"

H'Ree felt a chill. He chose his answer carefully, afraid that this might be a test of wisdom and that failure could bring disaster to himself and all those around him.

"Wise creatures who wish they were wild."

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He waited a long time while the Angel digested his words. "Can you be more specific?" he asked at last.

H'Ree felt as if the weight of the world had been lifted from his shoulders, though he wasn't sure why. The words spilled from his mouth like the afternoon rain as he told the tale of two day's passage along the Pelagi Road and the night between.

"Does this have anything to do with what you've been teaching them, Professor?" the older male asked. He was an odd-looking sort, as different from the other Angels as it seemed possible to be, with little fur on the top of his head and too much around the bottom. H'Ree was careful to listen to his words, sorting them out of the crackling babble that filled his ears. He could see that the question bothered Mark, the male Angel in charge. He wasn't surprised, considering that H'Ree already knew the answer to that question himself. He waited to hear Mark's reply translated for him by the Angel's mind-machine.

"I'm afraid it probably does," he said. "The Bakamaru are learning about democracy the hard way—experiencing it for themselves. I guess things got a little out of hand."

"I think a war of genocide and territorial acquisition is more than just 'getting a little out of hand,'" said Benz, the eldest Angel.

Mark's reply was interrupted by cries from the crowd. H'Ree looked up in time to see trails of smoke falling from the sky. Then flashes of light and flame appeared on the edge of the brush, followed a brief moment later by the chest-thumping *Boom! Boom! Boom!* of explosions.

"That looked like rockets," Benz said.

"Alysa," Mark yelled into his handphone. "Get the shields up."

"Shields?" Benz asked.

"We've got a defensive shield generator in one of the barns. Alysa is getting it warmed up right now. We can probably get a good share of the refugees under its umbrella."

H'Ree braced himself against another round of explosions, but they were replaced by the distant crackle of small arms fire and the far thunder of grenades. Nevertheless, he felt no fear. He had delivered himself into the hands of the Angels and it would be up to them to carry events further.

"The Pilgrims of the Way are basically a brotherhood of spies," Mark said as he cleared a seat in the nook of a nakok limb of debris and sat down. "They were founded by a tribal patriarch in Suridash—a fellow named Jobe who circumnavigated Chamal on foot. He sent them out to look at the world and send back word of what they saw. They've helped Suridash remain a free city for more than three centuries. In recent years, however, they've taken on some new responsibilities."

"They work for us?" Benz asked.

"Not directly. But they serve our interests."

His phone beeped at him, he opened it up to hear Alysa report that the forcefield generator was online. A moment later, the air crackled and the sky took on a deeper hue. "We're up," he told Benz.

The horde of chamalians uttered a soft sigh, then a raucous cheer as word spread that the shields were in place. The gunfire sounded more distant, even though F'Tan soldiers could be seen coming out of the woods far down the slope.

"And now what? Do we do more than protect the refugees? I mean besides teaching them civics?"

Mark winced, but ignored the barb. "There are procedures in place. This kind of thing is more common than you might think. Word spreads fast on Chamal. There are radios everywhere—and spies. The Space Corps enjoys cracking down on the little empires. It keeps them in practice and it reminds the big

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powers of what we can do. We've notified the *Cousteau* and a team will be here shortly."

He swallowed, then added: "And the lessons are suspended while the shields are up."

"Tell me, Professor, who decides what to teach?" Benz asked.

"They do," Mark said, realizing that what he said now would likely settle his fate with Benz. "They're really excellent students—once you get them to focus. Their minds are all over the place and they tend to scatter their energies easily. Then they grasp a whole set of interlocking ideas all at once and it's like watching the lights come on. And before long, everyone in the community understands the same thing. Ideas spread like a bad cold on Chamal. Or like chamalian genes."

"Are you sure it was a good idea to start doing this?"

Mark laughed softly. "You don't understand, Dr. Benz. We didn't start it, they did. They started analyzing us as soon as we arrived, trying to understand us the way we tried to understand them. The more they learned about us, the more they deduced. Before long, they were asking a lot of pointed questions that even the AIs couldn't help answering. And—"

Benz let one eyebrow raise as Mark hesitated.

"—and some of us did share books with them. Those raised a lot of questions."

"What kind of books?"

"Nothing technical, of course. Just some old novels, a couple of history books, a Bible, a Torah, and a Koran."

"And what are you teaching them, Professor Paradis?"

"This year it's democracy. They came up with it on their own, as I said, but they started asking a lot of important questions about how it has worked for us."

"Are you going to move on to capitalism next term?" Benz asked, his eyebrow now arched high.

"They know pretty much all there is to know about capitalism on this planet, Dr. Benz," Mark said. "That's one argument the textwars have worn into the ground. They've even got a few things to teach us about it. But we haven't gotten into any posteconomic systems, and we're not going to."

"They don't know about replicators, then?"

"Good lord, no," Mark protested loudly. "That would go beyond simple subversion and on into race betrayal. Give me credit for some sense."

"Is there any way to prove that?" Benz asked, an icy chill suddenly in his voice.

"Yes, sir. If we let that idea out, they'd be working on designs by the next morning. Believe me, if the chamalians start building replicator technology of their own, there'll be no hiding it."

Benz shook his head slowly, then sighed. "If that's true, then you're in the clear, Professor. If it's not, then you'll want to start packing your bags."

Mark swallowed hard, then looked up at the sudden *Boom-Boom-Boom* of a squadron of supersonic vehicles coming down out of orbit. In the distance, down by the Pelagi Road, the jungle erupted with flashes of silver light. A moment later, the thunder penetrated through the forcefield.

The refugee chamalians stirred on the grounds of Mark and Alysa's camp, rising to their feet with a thunderous roar of joy.

"What was that?" Benz asked.

"Stun bombs and electromagnetic-pulsers to incapacitate the soldiers and knock out their equipment."

"Very humanitarian of them," Benz said.

"We don't want to start killing them for killing each other," Mark replied. "It's part of our image. We have to act like angels if we want them to think we are."

A couple of days of rest and attentive nursing by the younger Angels did H'Ree a world of good. His wound was

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healing and they'd given him painkillers to eliminate his suffering. He was well-fed and slept on a proper mattress each night. And he was treated like a visiting king by Professor Paradis and Doctor Spenskaya.

But the old male Benz was still troubling to him.

He inquired about him among the younglings and learned that he was a scientist and a judge, come to decide the fate of the Angels. At first H'Ree shuddered at the thought of a being powerful enough to make such decisions. Then he watched Benz putter around the camp, poking his nose into things, asking eighty-eight questions a day about things that were obvious to any wiseling eight days out of the litter.

H'Ree realized that it was not the creature that carried the power, it was his position. As Angels went, he was actually quite congenial with the others, and he showed no indication of privilege or rank.

After he had uncovered all he could about Benz—and about his mission here on Chamal—H'Ree approached him one afternoon near the barnyard, where Benz was watching a pack of domesticated diggers eating their feed.

"Good day, Doctor Benz," H'Ree said softly. The speaker on his headset pronounced the words in the language of the Angels, which seemed to startle Benz out of his observations suddenly.

"Uh, good day to you too," he replied. "They call you H'Ree, the Pilgrim, don't they?"

"That is correct," H'Ree said. "And you are Benz, the scientist."

Benz bared his teeth in a smile. "That was quite an adventure you must have had getting here," he said.

"An adventure? The word implies both a harrowing experience and a fictitious tale. An odd clash of meanings—like many of your words."

"You're a linguist?"

"It's one of my duties as a Pilgrim of the Way," H'Ree said. "But in truth, I'm just a creature who has to go around sniffing at trees to find out what's there."

"Are you sniffing around here?" Benz asked.

H'Ree wrinkled his snout in a vain attempt to detect the scent of suspicion, then said: "Not at all. I've come to speak to you about Professor Paradis."

Benz was silent for a moment, which H'Ree took to mean he was surprised by the remark. "Yes?"

"I understand you are here to judge his work. To decide if it will continue."

"You understand quite a bit," Benz said.

"If you are to do that, then there is something you must understand."

"And what's that?"

"Mark Paradis is a creature with a good soul, but he is a poor teacher. I am afraid that he does not know the answers to many of our questions and is not truly prepared to help guide us away from our past and towards a new and different future.

"But in spite of that, you must not stop what he is doing. We cannot continue with only half of what your race can teach us. We must have it all, or the half we have been given will destroy us. I do not know that else your wisdom entails, but I do know that we must have it in order to survive."

"Is that so?"

"It certainly is. We are bound, your race and ours, by the Seed of God. You likely do not know our history, but recognizing this bond is an important part of what being a Pilgrim of the Way is all about. It is easier for us to see the bond. There are so many different kinds of us, and only one kind of you. So we are accustomed to the differences in size and shape and language. But underneath it all, we are the same. All creatures that know themselves share the same burden, the same problems. And one day, they all must share the same solutions—or they will destroy each other."

"Isn't there a danger in giving you too much?"

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"Too much? We are cursed with always having too much. And we are always a danger. We are thinking creatures, isn't that enough?"

"Perhaps it is," Benz said.

A few days later, before he prepared to leave for Suridash and then for home, Benz called them together, Mark, Alysa, and all the grad students. Mark felt his stomach tie itself in knots, and Alysa grew silent and sullen again, but there wasn't time for it to hurt either of them much.

They met in the dining room of the great house in the nakok tree.

"I don't want to waste your time or leave you in suspense, so I'll get right to the point," Benz said.

Mark could not read his expression and could not foresee his fate.

"Professor Paradis doubts my ability to make the right decision. But he does not know that I have read the philosophers. Or that I was Claudius when my quad put on *Hamlet*. Or that I play the oboe in the city symphony. I am just as much a humanist as he is, in my own way, and his doubts are not well-founded."

"And what does that mean?" Alysa asked.

"It means that reason is indeed stronger than fear, ignorance, and desire," Benz said directly to her before addressing the group. "Now, when I return to Earth, I will make a report about the shortcomings in your research project and recommend ways to alleviate them."

"Shortcomings?" Mark asked, sudden fear chilling his veins.

"Yes, shortcomings," Benz said with a smile. "First of all, Dr. Spenskaya's equipment and staff are inadequate to her task. She needs a quantum imager and a microbiology lab so she can watch germ cells and zygotes and find her telomeres. And a team to operate each of them."

Alysa let out a yell, then choked it back, clutching her hands to her mouth.

"And Professor Paradis would be much better off if he had some grad students in history and political science to help him teach the chamalians how to be more human. Is three of each sufficient?"

Mark let his jaw drop and forgot to pull it back up as he nodded slowly up and down. In one instant, his fears were demolished, his hopes uplifted, his doubts dispelled, and his heart restored.

"More than sufficient, Dr. Benz. And thank you very much." □

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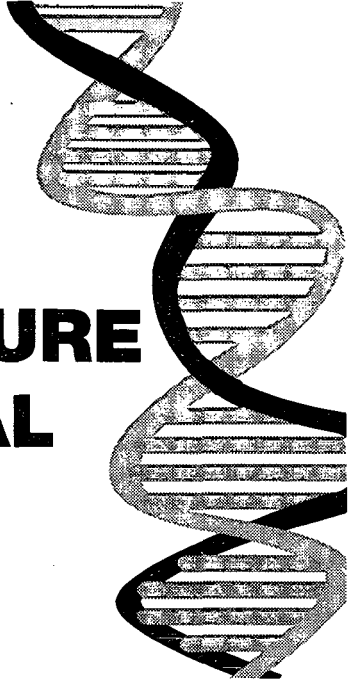
Richard A. Lovett

Tricorders, Yactograms and the Future of Analytical Chemistry



When "Nano-" Isn't Small Enough

There are few scientific disciplines more maligned than analytical chemistry. In college, science majors are often forced to dabble in the field, but few enjoy it. Perhaps it's because their encounters typically occur in the frightening context of being handed vials of "unknown" white crystals and having to spend weeks trying to figure out what they are—with lab grades hanging in the balance. A few people thrive on the challenge. Most mop their brows and mutter, "Never again."

Superficially, science fiction shares this "good riddance" attitude. Try asking fans to name a favorite analytical chemistry story. Most will be hard pressed to think of a single example, let alone a favorite.

But the appearance is deceptive. Consider the movie *Gattaca*. It depicts a culture in which instant gene-typing has produced an oppressive *Brave New World*. That DNA-worshipping culture only functions with the help of cheap analytical techniques that allow everyone to be subjected to instant gene checks descended from those the Los Angeles prosecutors used in attempting to track O.J. Simpson's blood.

Science fiction is replete with examples of analytical chemistry in action. It's just not as noticeable as astronomy or biology because it hides in the background. *Star Trek* is a prime example. The crew's tricorders are pocket analytical laboratories of amazing sophistication. And many a criminal, in speculative fiction as in the real world, has been tracked down by police labs using forensic applications of basic analytical chemistry techniques. The not-that-distant future could see tricorder-like devices that can name everyone who's ever been in a room, or function as bloodhounds—without the need for dog food.

Historically, analytical chemistry has been done with expensive laboratory equipment such as the gas chromatograph and mass spectrometer, which separate molecules by their physical properties.[1] But for more run-of-the-mill purposes, the future belongs to disposable test kits that can be mass-produced for pennies apiece.

The key to these methods is chemical

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nanotechnology that mimics the functioning of biological systems. Some of this technology already exists, and more will be on-line before the end of this century. But before we discuss the details, let's look at a few basic terms and principles:

• The "analyte" is the substance whose presence we're seeking to establish. It needn't be a chemical; there is growing interest in using chemical techniques to detect bacteria and viruses. The important point is that tests are designed with specific compounds or classes of compounds in mind. This is partly because life is unlikely to hand you the reasonably pure mystery substance beloved of organic chemistry lab instructors. More likely it will be something messy—food, dirt, blood or a murder weapon—that may be contaminated with "microsmidgens" of something important, such as a toxin, virus, chemical residue or O.J.'s blood. "Tell me everything that's present," just isn't a practical request.

• The "matrix" is the chemical soup containing the target analyte. Unfortunately, it may also contain components that interfere with some tests. In the tests used for food nutrition labels, for example, high-fat/low-protein foods often have to be treated differently from low-fat/high-carbohydrate foods. Fortunately, "matrix interference" is more of a problem with older-style chemical tests than the nanochemical methods we'll be discussing below.

• Some tests are "qualitative," meaning they give simple "yes/no" verdicts on whether an analyte is present above a certain threshold, called the "level of qualitative detection." This, incidentally, isn't the point at which some piece of lab equipment reads "zero." Rather, it's the level at which, given random fluctuations in the test's output, there is a reasonable certainty the "yes" verdict isn't a statistical fluke.

• A "quantitative" test, on the other hand, gives the amount of chemical present. Not surprisingly, it has a "level of quantitative detection." Quantitative results are usually given as concentrations. Lay reports typically state these as parts per thousand (ppt), parts per million (ppm), parts per billion (ppb) or even parts per trillion (ppt), but in the technical literature, results are often given in the "moles" and "molarities" that are the bane of high school chemistry students. All you need to remember, however, is that a "mole" is a specific, very large number of molecules (6.02×10^{23}). A 1.0-molar solution contains one mole of dissolved molecules per liter.

Prefixes of Increasing Nothingness[2]

In the analytical chemistry world of the future, small is beautiful. Chemists want tests that use the tiniest possible samples, with the lowest possible levels of detection and/or quantitation. Since World War II, it has been estimated that analytical techniques have been increasing in sensitivity at a rate of about three orders of magnitude per decade—a trend that is, if anything, accelerating.

One result is a growing collection of wonderful prefixes. Any *Analog* reader already knows that "milli-" means 1/1000, "micro-" means 1/1,000,000 and "nano-" means 1/1,000,000,000.

But what comes after "nano-?" The answer is "pico-," followed by "femto-," both of which are already in widespread use in terms such as picograms and femtomoles. To put this in context, searching for molecules at the femtomole level is equivalent to seeking out fractions of a penny in the national debt. And "atto-" (a prefix that means one part in 1,000,-

[1] *For a heavily illustrated summary of these and other methods, see Georg Schwedt,* The Essential Guide to Analytical Chemistry *(John Wiley & Sons) 1997.*

[2] *I owe this phrase and much of the information in this section to Indiana University professor Ronald Hites, who used it at the 1994 annual meeting of the American Association for the Advancement of Science.*

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Table 1
Prefixes of Increasing Nothingness

Prefix	Meaning (scientific notation)	(decimal)
milli-	10^{-3}	.001
micro-	10^{-6}	.000001
nano-	10^{-9}	.000000001
pico-	10^{-12}	.000000000001
femto-	10^{-15}	.000000000000001
atto-	10^{-18}	.000000000000000001
zepto-	10^{-21}	.000000000000000000001
yacto-	10^{-24}	.000000000000000000000001

000,000,000,000,000, or 10^{-18}) no longer raises eyebrows in the technical literature.

Table 1 lists eight such terms. It's useful to note that an attomolar solution contains fewer than 1,000 molecules per cubic centimeter, or one molecule per microliter. At this level we're starting to bump into the "lumpiness" of nature at the molecular level—a true indication we're beginning to deal in nanotechnology. At the yactomole (10^{-24}) level, for which tests could be on line in less than two decades, it would take more than a liter of solution to find a single molecule. A yactogram is slightly less than the mass of a hydrogen atom. A chemical bloodhound box that could track body odors or DNA at these levels would be a potent tracking device indeed.

Antibodies, Dolly, and ELISA (not Doolittle)

Hypersensitive methods for detecting trace analytes in complex matrices are based on imitations of the way animal immune systems detect trace amounts of foreign substances in the blood.

The immune system functions, in part, by creating chemical agents called antibodies, which bind to invading substances, be they viruses, bacteria or environmental chemicals. Antibodies are extremely selective, binding only to the target compound (and perhaps a few structurally similar molecules). They bind only to a small portion of the molecule, called the binding site; more than one antibody can bind to the same molecule by binding at different sites.

Analytical chemistry harnesses antibodies via a group of tests called "immunoassays." (The prefix "immuno-" indicates the test's connection with the immune system.)

The hardest part of any immunoassay is obtaining the necessary antibodies. Classically, this is done by exposing an animal—perhaps a rabbit or sheep—to the target analyte. The sensitized animal then produces antibodies that can be isolated from its blood.[3]

Antibody production from animals, however, is a bit hit or miss. One sheep may produce a large quantity of powerful antibodies; another may produce fewer, weaker antibodies. And the good producers don't live forever. When a large, consistent supply of antibodies is wanted, a better source is from cell cultures. Recent advances in cloning, however, may bring mammals back into the picture, at least for some uses, by allowing the best antibody-producers to be perpetuated via clones. (Dolly the sheep may have her uses!) Today it is also possible to force the production of antibodies for substances that do not normally provoke immune responses.

Immunoassays work by using antibodies that are selective for the target analyte. The best analogy is to fishing: the antibodies are nanochemical "hooks" baited for a very specific type of chemical "fish." They can be used to selectively snag the target analyte from a complex chemical sea teeming with other species. Once this is accomplished, all that remains is to find a way to measure the size of the catch.

There are a variety of ways of doing this—enough to fill entire books of laboratory techniques. One of the most common in commercial test kits is the

[3] *The same approach is used with horses to make antivenoms for snakebite.*

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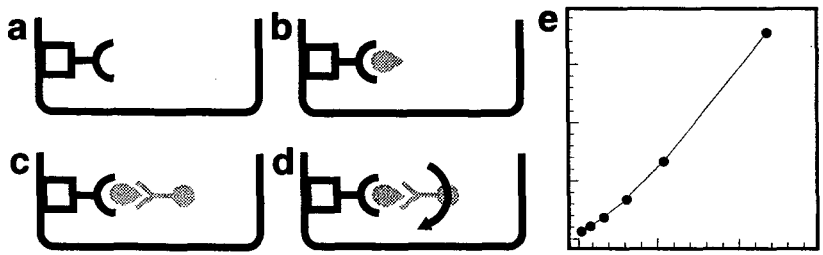
Figure 1



ELISA test surface is baited with antibody "hooks" (a) that catch analyte molecules from the test solution (b). Enzyme, attached to second antibody, fixes to antibody-analyte conjugate (c). Remaining free enzyme is washed away. Substrate is added for processing by enzyme (d). Part (e) shows a typical plot of color changes vs. analyte concentration.

ELISA test—an acronym for "enzyme-linked immunosorbent assay" (Fig. 1).

ELISA kits use thimble-sized "test wells" or tongue-depressor style "dipsticks" whose surfaces are sprinkled with molecules of the desired antibody, firmly attached to a plastic backing. The sample to be tested needs to be dissolved or finely suspended in water—something that can be done easily enough with the aid of an electric blender.

In one of the more common forms of ELISAs, called a "sandwich" ELISA for reasons that will soon become obvious, a small amount of the solution being tested is placed in the test well–or for dipstick tests, into a sample bottle into which the dipstick can be inserted. The antibodies on the test surface bind to molecules of the target analyte, tethering them to the surface. (Fig. 1.) Now, a reagent is added which contains a second antibody specific for a different site on the target analyte. This antibody is chemically bonded to an enzyme in a manner that doesn't affect either the function of the enzyme or the analyte's ability to link with the antibody. (Enzymes are organic catalysts that quickly convert one molecule, called the "substrate," into another, called the "product," without themselves being consumed by the reaction.)

This second antibody links with the analyte molecules, carrying the enzyme along with it. The result is an antibody1-analyte-antibody2 sandwich, firmly attached to the plastic surface. The enzyme, which so far has merely followed along like the tail of a dog, is also firmly attached to this antibody sandwich. In fact, the whole purpose of this process has been to attach the enzyme to the tethered analyte molecules in a 1:1 ratio.

The test well or dipstick is now rinsed to remove excess antibody/enzyme reagent (that which failed to find analyte molecules with which to link). A second reagent is added, this one containing the enzyme's substrate.

The enzyme has been chosen so that it converts a substrate of one color into a product of a different color. The speed and extent of the resulting color change is a direct measure of the amount of enzyme present—and hence the amount of the target analyte. For a quick-and-dirty estimate, the color change can be eyeballed against a handy pocket chart. Or it can be measured more precisely with a laboratory instrument called a "colorimeter." Such tests routinely achieve sensitivities on the order of parts per million or below.

Enzyme immunoassays can be developed for any analyte for which antibodies can be created. This includes pro-

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teins, bacteria[4], viruses, pesticide residues, drugs, and a host of other organic compounds. In addition to the ELISA discussed above, there are radioimmunoassays (which use radioactive tracers instead of enzymes) and immunofluorescence tests (which use enzymes whose substrates fluoresce under ultraviolet light). These are more sensitive than an ELISA, but are more difficult to package for use as no-brainer field tests.

Anyone who's ever used a home pregnancy kit has used an ELISA. The kit works by detecting a hormone in the urine of pregnant women. In the old days the urine sample was given to rabbits that had been sensitized to be hyperallergic to that protein. If the rabbit went into anaphylactic shock, the protein was present (remember the old phrase, "The rabbit died"?). Today, the rabbit can live because all that's needed are its antibodies, affixed to the surface of the home pregnancy kit.

Similar home-use test kits are the wave of the future. Already, an Internet search for "enzyme immunoassay" will reveal a host of manufacturers selling test kits for hundreds of organic compounds, often at less than the price of a good dinner (although most of these kits aren't currently intended for home use). Some are quite innovative. At the spring 1995 meeting of the American Chemical Society, for example, one group of researchers introduced an ELISA for insect infestation of stored grain or vegetables.[5] To test for insects, they simply homogenized the food in a blender and used antibodies specific for insect myosin, a muscle protein present only in insects.

Counting Molecules "One-Two-Three"

ELISA tests are limited by the need to produce noticeable color changes in milliliter-scale samples. That may work down to a few parts per billion, but that's still a detection limit on the order of 100 million molecules or more. The Holy Grail of analytical chemistry is a test that would detect a far smaller number of molecules—ideally a single one.

A remarkably simple method of single-molecule detection was pioneered a couple of years ago by researchers at Iowa State University, who demonstrated that it can detect single molecules at the attomole (10^{-18}) level.[6] The technique currently isn't suitable for field kits, but that may not be a long-term obstacle. Not much more than a decade ago, ELISAs that can be done in ten minutes today required a Ph.D. and a well-equipped research lab.

Like an ELISA, the single-molecule detection method is enzyme-based, but it uses an enzyme that produces a fluorescent product that is detectable at extremely low concentrations, on the order of a picomole.

The limiting factor with previous fluorescence assays was that the fluorescent product disperses through a sample large enough that it could take days for a single enzyme molecule to produce even a picomolar concentration of fluorescent product. The Iowa State researchers' brainstorm was to reduce the sample size dramatically by placing it in a thin glass tube called a "capillary tube," 10 micrometers in diameter, with a volume of 290 nanoliters (for a half-meter length).

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[4] *Mary Kalamaki, Robert J. Price and Daniel Y. C. Fung, "Rapid Methods for Identifying Seafood Microbial Pathogens and Toxins," Journal of Rapid Methods and Automation in Microbiology, 5 (1997) 87-137.*

[5] *"ELISA Test Developed for Insect Contamination," Food Chemical News, 37(7), April 10, 1995, pp. 8-9.; or R.A. Lovett, "Food Industry Goes Crazy over ELISA," The Referee (members' newsletter of the Association of Official Analytical Chemists), 19(8), August 1995, pp. 2, 22-23.*

[6] *Qifent Xue and Edward S. Yeung, "Differences in the Chemical Reactivity of Individual Molecules of an Enzyme," Nature, Vol. 373, February 23, 1995.*

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To count the number of enzyme molecules in the tube one simply lets the enzyme chew away at its substrate for a few minutes. The narrow tube effectively immobilizes the large enzyme molecules, while simultaneously causing the product to accumulate in fluorescent "hot spots" that can be counted with the aid of a simple magnifying glass. The only problem comes if there are so many enzyme molecules that the hot spots start to overlap, but this can be resolved by redoing the test with a more dilute sample.

Counting enzyme molecules might not sound all that exciting. But remember how the ELISA test links enzymes to antibodies to fish out the target analyte from its chemical sea. The same can be done here by adding enzyme-antibody conjugates to the matrix being tested, so they can bind to the analyte on a one-to-one basis. The major technical difficulty is that because these antibodies aren't affixed to an immobile surface as they are in an ELISA, the unbound enzyme can't be removed by simple washing. And it is critical to remove the unbound enzyme because otherwise its molecules will be added to the final count.

Methods must therefore be developed for separating antibodies that have "hooked" the analyte from those that haven't, and at the single-molecule level of detection this separation must be nearly perfect. For viruses and bacteria, this isn't all that difficult because they are large enough to be separated from liquid media by filtration. (It doesn't matter if the filtrate is contaminated with non-target viruses or other large particles, because they will show no enzyme activity.) For smaller analytes, perfect chemical separation at extremely low concentrations poses more of a challenge, but probably not an insurmountable one.

Separation techniques will also allow chemists to "condense" extremely dilute samples by combing the target analyte out of the solution. Imagine being able to find a single molecule of pesticide residue in an apple, a single *Salmonella* bacterium in a liter of milk, or a single HIV particle in a blood sample.

Whether society will benefit from the ability to detect single molecules in swimming-pool-sized samples is a question that might be the subject of an interesting story. At this level of sensitivity there's probably "something" of virtually "everything" in any given sample, particularly for ubiquitous environmental contaminants like pesticides or dioxin. Being able to measure these trace contaminants may simply instill panic in people who don't understand the fundamental axiom of toxicology: "The dose makes the poison."

Chasing O.J.'s Blood

Immunoassays won't work for gene testing because all they'll tell us is what we already know: that we have a sample of DNA. Generally, we want something a lot more specific, such as *whose* DNA it is. That requires a whole new breed of tests, which can only be summarized briefly in this article.

These tests make use of two aspects of DNA biochemistry: DNA's self-replicating nature and its ability to bind selectively to matching nucleotide sequences. The first of these properties allows "enrichment" of low-concentration DNA samples by forcing the DNA to replicate in the lab—running it through as many replication cycles as necessary to obtain a testable amount. Each cycle takes only a few minutes, allowing a million-fold replication in about three hours—quickly producing a testable amount of DNA from a single cell. The process can be done in automated machinery.

This enrichment mechanism, called "PCR" (for polymerase chain reaction), is one of the most powerful tools in the DNA-testing arsenal. It's even possible to force only chosen portions of the sample to replicate—a nifty trick for sepa-

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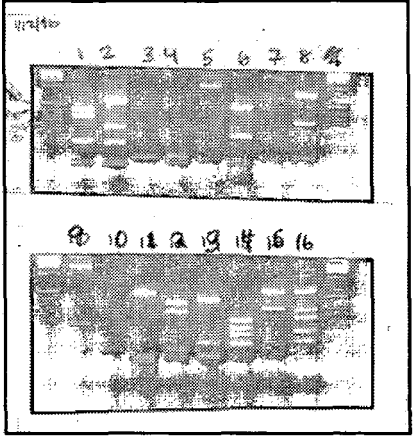
Figure 2
DNA fingerprint



rating human DNA from that of cockroaches, mice, cats or dust mites.[7]

Once we've made a few thousand or million copies of the DNA segment of interest, we can mix it with a DNA test probe that will seek out and bind to matching DNA sequences. If we're looking for a specific gene—such as a marker for a particular type of pathogenic bacteria—these test probe molecules may contain a substantial fraction of its coding.

But more likely we don't know what gene we're looking for—and don't care. All we want to know is whether we've got a sample of O.J.'s blood (or that "presidential DNA" of Monica Lewinsky fame). For this, we only need a test probe with a half-dozen or so nucleotides attached to an enzyme that snips DNA in strands in half. The test-probe DNA latches onto its target base sequence wherever that sequence occurs randomly, allowing the enzyme to cut the DNA strand at that point. The result is a stew of DNA fragments of varying lengths that can be separated by a form of chromatography called capillary electrophoresis. The relative amount of each length is a DNA fingerprint that can be used in determining the DNA's source (Fig. 2).

In addition to its obvious use in police labs, gene testing is valuable in epidemiology, where it can be used to track bacteria strains by their DNA fingerprints. It can also be used in sanitation and hygiene testing to determine whether the pathogen that's getting into a supposedly sterile food product comes from dirt on the floor, condensed steam dripping off a ceiling, or a barnyard—or even *which* barnyard.

Police detectives of the future may even have portable DNA sniffers that scan carpet sweepings or hair follicles for DNA fingerprints of known felons.

A Functioning Analytical Nanomachine

A revolutionary technique that might greatly increase the speed and sensitivity of many types of tests was unveiled in the summer of 1997 by a group of Australian researchers. Not only is this technique a revolutionary advance in analytical chemistry, but it is also a major advance in nanotechnology, using the world's first functioning nanomachine, complete with molecular-sized moving parts.

As originally unveiled, the device, called an "ion channel switch biosensor" (or "ICS biosensor"), is a novel immunoassay, although in theory it can also be used as a gene probe. Its chief step forward is that it produces an easily measurable electrical output rather than a change in color or fluorescence.

The sensor is modeled on a bacterial cell membrane. At its heart is a molecule called gramicidin, which forms molecule-sized ion "pipelines" capable of rapidly transporting large numbers of ions across an otherwise non-conductive one-molecule-thick membrane. Two gramicidin molecules can link together to extend the ion pipeline through two layers of membrane.

The biosensor consists of several lay-

[7] *Genentech maintains a very informative, searchable Web site on this and other aspects of DNA biochemistry. See www.gen.com/eu/.*

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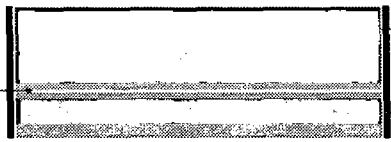
Figure 3
The ICS biosensor in use

The biosensor consists of a non-conducting membrane separating two conducting solutions

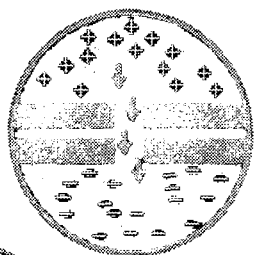
The membrane prevents conduction between the two solutions



Solution 1
The test solution containing target molecules

Solution 2
The internal reservoir

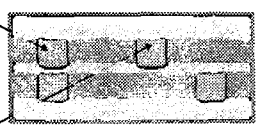
Ion channels in this membrane serve as molecular "pipelines" conducting large numbers of ions through the membrane

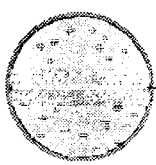


Each ion channnel can convey up to a million ions per second: this change in conduction can be triggered by the detection of a single molecule

A closer examination of the membrane shows that it consists of two layers, with separate "half" pipelines or "half-channels" penetrating each layer. Lower half-channels are tethered to the membrane's base and cannot move. Upper half-channels are free to move. If the upper and lower channels align, current flows. If not, current is blocked.

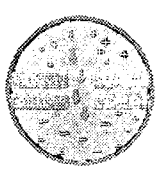
When the channels align, current flows



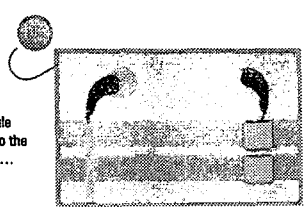


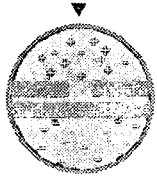
When the top and bottom half of the channel are separated, current is blocked (ie impedence rises)

Antibodies attached to the membrane can hook to different locations on the target analyte. One such antibody is tethered to a fixed location, via a long molecule, called a "membrane spanning lipid" whose other end is affixed to the membrane's gold-plate backing. The other is attached to the upper, mobile half-channels. When both antibodies attach to the analyte, the upper half-channel is pulled out of alignment with the lower half-channel and the flow of current is cut off.

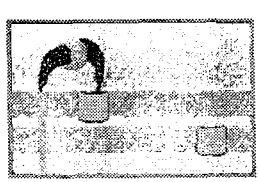


The target molecule is first anchored to the membrane's base...





Then it attaches to a mobile half channel – effectively anchoring it



Thus conduction is broken, since the two halves of the channel cannot join

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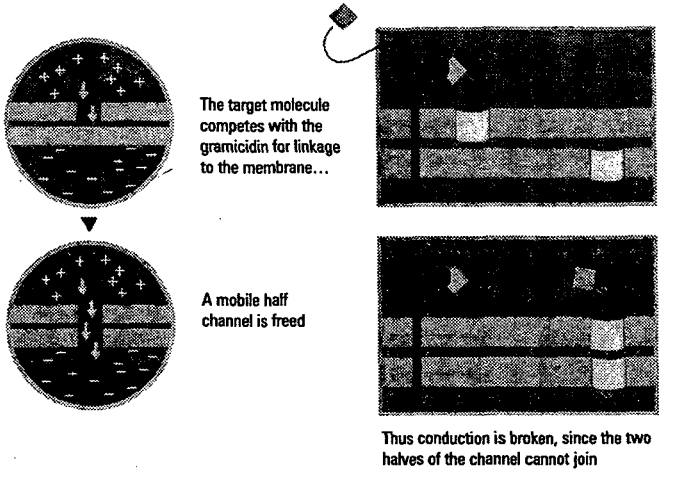
Figure 4
Competitive assay


The target molecule competes with the gramicidin for linkage to the membrane...
A mobile half channel is freed
Thus conduction is broken, since the two halves of the channel cannot join

For this smaller-molecule test, the membrane is again prepped with antibodies, but this time the antibodies of interest are only attached to the membrane-spanning lipids. The mobile, upper half-channels are permanently bonded to a close chemical analogue of the target analyte, shown here as a diamond. In the membrane's "neutral," pre-test position, the analogues and their attached half-channels find the antibodies on the membrane-spanning lipids and are pulled out of alignment with the lower half-channels. Thus, the natural state of the test membrane is in the "off" or "no current" position. When the actual analyte is introduced (also shown as a diamond), it chemically competes for linkage to the membrane-spanning lipids, dislodging the molecules of analogue attached to the upper half-channel. Each time this happens, it frees an upper half-channel to connect with a lower half-channel, opening the flow of current.

ers affixed to a plastic backing such as a thermometer-like test probe. The lowest layer is an extremely thin gold film that provides a conductive base for electrical measurements (Fig. 3) Next comes a honeycomb-like spacer that acts as a reservoir for conductive ions. This is followed by the two-layer membrane. The lower layer is firmly tethered to the gold base and contains a scattering of gramicidin molecules, also tethered. These gramicidin molecules are best thought of as "half" ion channels because they penetrate only half of the total membrane.

The upper membrane layer also contains gramicidin molecules, but these half-channels are free to move by diffusion across the membrane's surface (which should be thought of as a viscous liquid rather than a solid). They have an affinity for their lower-membrane counterparts and will try to align into "full" channel pairs, penetrating both layers of the membrane. These full channels are the electrical pathways through which current can flow when a conducting solution is placed on top of the membrane.

To make the membrane work as an analytical devise, antibodies are used to cause the gramicidin pairs to join or separate depending on the presence of the target analyte. This creates a population of on/off "switches" that allows easy, quantitative measurements of the analyte's concentration, based on the membrane's electrical conductivity, with sensitivities limited only by the ability to measure minute electrical currents.

Antibodies can be included in one of two ways. To test for large substances

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such as proteins, viruses or bacteria, the upper membrane is peppered with two types of antibodies binding to separate sites on the target analyte. One is anchored to a long molecule called a "membrane-spanning lipid" that traverses both layers of the membrane and is tethered to the gold-plate backing. Its job is to hold the target analyte in a fixed location. The other antibody is attached to the upper, "mobile" half-channels. When it binds to an analyte that is already bound to a membrane-spanning lipid, it drags the attached half-channel away from its lower half, interrupting the flow of current—like pulling the plug on an electrical appliance. (Fig. 3)

A second version of the test, called a "competitive assay" can be used for molecules that are too small to allow the binding of two antibodies, such as pesticides or drugs. For these analytes, antibodies are used whose bonds with the analyte are weak enough to be repeatedly created and broken, again and again in rapid sequence. These antibodies are attached solely to the anchored, membrane-spanning lipids. (Fig. 4.)

Attached to the mobile half-channels is a chemical analogue of the target analyte. The analogue binds loosely to the anchored antibodies of the membrane-spanning lipids, again pulling the attached half-channel out of reach of its lower-membrane partner. This antibody bond, however, is so weak it lasts only a few seconds. The membrane has many antibodies, so each time a link breaks, it reforms with a new antibody, keeping the upper ion channel out of reach (most of the time) of the lower membrane's half-channels. Thus, in the competitive assay, the natural state of the membrane is the "off" (or no-current) position.

When a sample containing the target analyte is placed on top of the membrane, that compound competes with the analogue for attachment to the antibodies. This frees some of the mobile half-channels to move through the upper membrane, linking with lower half-channels to switch on the membrane's conductance. The number of channels that switch "on" is related to the concentration of the target analyte.

By adjusting the number and types of antibodies and channels in each of these assays, membranes can be designed with sensitivities that range from micromoles to less than a picomole. Also, the conductivity of the ion channels is so high that only a very small piece of membrane is necessary to produce measurable results, opening the prospect of adapting the test for use with hair-thin test probes. Larger probes can reused by incorporating the membrane into inexpensive, disposable plastic covers.

The ICS biosensor allows quick, quantitative tests for any substance detectable with an antibody, with direct electrical readouts that beat conventional immunoassays for sensitivity and ease of use. It should also be possible to modify the membrane to replace the antibodies with DNA probes or chelators (for measuring heavy metals).

By preparing biosensor probes with more than one test site, it should even be possible to test for numerous chemicals at once, obtaining multiple readouts simultaneously. Response times would depend on the size and concentration of the analyte but would seldom exceed five to ten minutes. For smaller molecules using the faster-reacting competitive assay, there's no reason the device couldn't provide continuous monitoring, with a response time of about a minute.[8]

The Twenty-first Century and Beyond

So what's the future of analytical chemistry? The trend is obviously toward increasing sensitivity and speed—packaged in user-friendly kits that minimize the need for specialized training.

[8] *For more information, see the researchers' Web site at www.ambri.com.au/institute/technology/ics/index.html.*

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Also, just as ELISA has become commonplace in the 1990s, single-molecule detection is likely to become increasingly common—particularly through electrochemical methods like the ICS biosensor that eliminate the need for elaborate glassware or even a lab bench.

There may also be a rise in kits that screen for multiple chemicals at once or provide simultaneous, independent results on dozens or hundreds of analytes. Such kits would be particularly useful in pesticide residue testing or testing for use of banned drugs by Olympic athletes.

Miniaturization, mass production and an emphasis on reusable hardware will lower manufacturing costs to nearly zero, but high R&D costs will still have to be amortized, slowing the drop in test kit prices. But development of inexpensive, easy-to-use test kits may have a number of significant social impacts.

Medical applications, for example, will make it possible to do continuous blood chemistry tracking of a host of analytes. This will first occur in hospital intensive care units or operating rooms, but should quickly lead to such gadgets as surgically implanted blood-chemistry monitors that provide continuous blood sugar read-outs for diabetics or warn cardiac patients of impending heart attacks.

Home-use tests will become more and more common. Are you afraid a leftover casserole might not be safe to eat? Just use a handy electrical probe to check for dangerous bacteria. Are you concerned about organic solvents offgassing from your new paneling or carpet? Just install a smoke-detector-like monitor that feeds a continuous output to your home computer. Such gadgets may simply fuel what the chemical industry calls "chemophobia," but technologically, they are close enough to reality to be on the market in the first half of the next decade.

Forensic devices such as the DNA sniffer or an electronic bloodhound that can follow individual people's body odor by yactomole chemical residues are farther in the future. A portable DNA sniffer, for example, won't work instantly if it needs to rely on PCR methods to enrich a sample to testable levels. But a portable device that produces results in less than half an hour might be possible, particularly if it somehow uses a quick, gene probe version of the ICS membrane to produce an electrical DNA fingerprint, instead of a slower, less sensitive process like electrophoresis.

The electronic bloodhound is less practical with present technology. Unless the government maintains a stock of presynthesized antibodies sensitive to all citizens' body odors (wonderful thought), a fugitive's trail is going to get very cold while reagents are being prepared. More likely, such a gadget will need to await a new "electronic nose" technology, perhaps based on a mixture of immunochemistry and the biochemistry of the real bloodhound's sense of smell.[9]

The same electronic nose technology may enable us to build a broad-spectrum, portable analytical laboratory with some of the functions of a tricorder. But the tricorder of the twenty-first century will still need to "smell" or "taste" the target analyte—something that can't be done by through walls or vacuum as is commonly done in *Star Trek*. The twenty-first century is likely to see a continuing revolution in our ability to detect what's happening in the unseen chemical world, but common SF concepts relating to remote sensing probably will remain in the realm of technological magic. ■

[9] *Such technology is, in fact, already under development, with sensitivity comparable to a real bloodhound's nose. To function as an electric bloodhound, however the eledtronic nose will need to have a nearly instantaneous response time and be readily programable to search for a diversity of aromas.*

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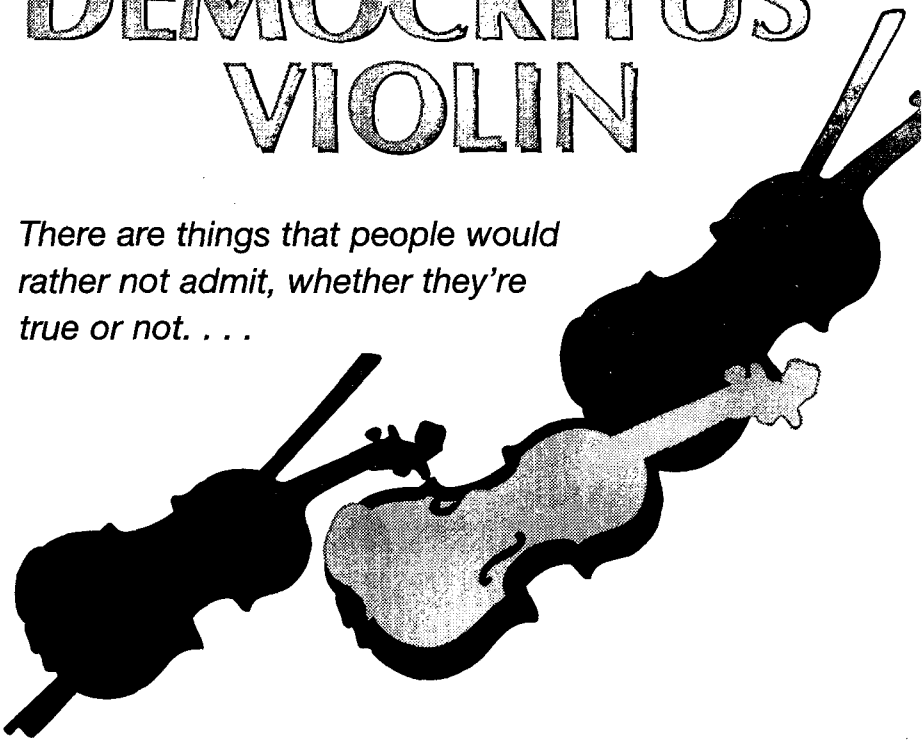
G. David Nordley

DEMOCRITUS' VIOLIN

There are things that people would rather not admit, whether they're true or not. . . .



"The whole is greater than the sum of its parts," Dr. Andre Stevens declaimed with sharp vertical movements of his hands punctuating every word. "There is an *ineffability* to some things, a spiritual content if you like, that laughs at the efforts of small-minded reductionists to dissect and explain them away. Words like chaos simply hide the truth that there are things which cannot be known by their parts, but emerge from something greater and can, perhaps, be *felt* and be appreciated by those who open themselves to it."

His words were addressed to the class as a whole, but seemed aimed at me in particular. I shrank from view, as much as ever conscious of my six-foot-one, ostensibly female body and my straight black hair. I hid my eyes in the paper on my desk as he spoke.

It was marked "C-minus" right next to the K. Kim. My name was my Korean-American parents' solution to multicultural sexual ambiguity—Kim Young Kim supposedly worked anyway you cut it. How clever. Couldn't they have anticipated me being called "Kimykim!" for twelve torturous school years? Ever since I'd had a say in it, my name was "Kay" to anyone that was my friend.

Back to the paper. I had dared to dissect Bach, citing recent analysis of how the brain triggers endorphin release in response to acoustical harmonies as well as optical symmetries and reasoning that a healthy voice is tonal (because

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of the way healthy vocal chords are), so less indicative of a diseased person, and so more attractive.

Stevens' comment was that I'd researched irrelevant trivia and shown no *feel* for the subject at all. Bach's music, he said, is beautiful because of its whole, not its parts.

I probably should have cited some of Stevens' writings in my paper, but they were all just collages of quoted postmodern generalities with nothing specific on which to reason, predict, or test. As a microtechnology engineering major, I was underwhelmed.

"The point of *holistic comprehension* in the arts," he continued with a pleased smug grin on his face, "is that reductionism has failed; things too complex for humans to understand must be appreciated at another level—a transcendent, holistic way of knowing that defies this nit-splitting analysis. The whole is more! In this music course, those who deny the ineffable are, most definitely, effable!"

A round of groans grew into general tittering. Stevens cleared his throat and continued.

For the thousandth time, I wondered why I hadn't signed up for the archeology course. Archeology always fascinated me because it was one area where culture and technology go hand in hand—indeed, before writing, culture and art are *defined* by technology—the Stone Age, the bronze age. While the "two cultures" are as old as the academic trivium and quadrivium, I saw the pathological split represented by Stevens as a modern invention; Jefferson and Franklin, for example, were both competent scientists of their age as well as competent writers and philosophers. And archeology used all sorts of hard science techniques to study things—dendrochronology, radioisotope dating, spectroscopy, radar imagery—it was much more my kind of thing. But that was the problem; at the time, it seemed too close to a hard science, and my advisor thought I needed broadening.

Dear Old Lloyd College was into anything Welsh, of course, and music in particular was supposed to stir the souls of the Men and Women of Harlech. Well, that and poetry and politics. If it came out of the mouth, it was us. Besides, I had a crush on Felix Mendelssohn—never mind that he died a couple of centuries ago at the age of thirty-eight.

"Come to my concert," Stevens droned on, "and I will show you, or," he gave slight chuckle of phony self-deprecation, "try anyway. And listen to my Stradivarius, if not to me or to Schoenberg. People have picked apart and tried to analyze his violins for over four centuries, and they can't duplicate them. No, they can't. Not all the analysis in the world will make another Stradivarius, and I'll give an A in this course to anyone who can prove otherwise!"

The bell released me from my music appreciation requirement to the more rational world of quantum mechanics. I bundled myself and books against the snow and the bitter Minnesota cold, stepped out into the tundra between the Fine Arts building and the Jobs Science Hall, and kicked the nearest ice chunk halfway to Minneapolis. Just because I *knew* all about endorphins and evolutionary behavioralism didn't mean I didn't have them.

I didn't need a "C" in anything this semester. My scholarship was in jeopardy. Mom's back didn't let her work anymore and Dad—well, lugging boxes around was about Dad's speed these days. Therapy make-work that robots could do better and cheaper. It hadn't always been that way, Mom tells me. If they could just get in his head and fix what that kid's bullet had done. If they could just fix the head of the kid with the gun. Who's "they?" I'd asked myself. Then I'd looked at myself in the mirror and chosen a major.

Maybe it was more than I could do. C-minus. I wanted a shoulder to cry on. Ted's.

As boyfriends went, Ted was about

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my speed. Charming, polite, and honest—about dating other girls and not being ready for an exclusive relationship. But we took classes together, hung out together, and it was pretty generally conceded that we were an item. I hoped. He was, at least, a full inch taller than me, and while not a football player, he'd lettered in track and field—throwing the discus.

He made me do weights to fill out my chest with something and taught me to throw the discus, I threw one sixty meters, which was a mistake because he tried to get me to join the women's team. Doing the jock thing in public didn't fit my self-image—I didn't like being reminded that I had failed to become the delicate Eurasian beauty Dad had wanted.

I found Ted sitting on cushioned bench in the hall just outside the nano lab with his head in a book.

"Hi, Teddy, got a moment?"

"Uh? Oh, Kay." He pushed a strand of jet-black not-too-clean hair from his brow. Since all the adults were wearing short hair in reaction to the previous generation, we were growing ours long again to make a statement to *them*. Silly, but style is style.

He looked into my eyes and knew. "Stevens again?"

"It was just too much, Teddy. He was ridiculing me and my ideas, and he's wrong! This whole idea that you can't understand how things work except by some mystical . . ." I sang an approximation of the Twilight Zone theme, "...comprehension is complete maximum nonsense that really only amounts to people getting their content-free arguments published by force of personality and politics and no one seems to know that particular emperor's not wearing any clothes!"

"That's heavy, Kay," he said with a grin.

I grimaced. "Well, thanks for listening, anyway. I just want to *do* something. But you can't prove anything to these people because the only proof they accept is how they feel and you know how *that's* going to come out!"

"Hmm."

When Ted starts going "hmm," I perk up. Another thing I like about Ted is that he shows signs of being an okay provider. I mean, I intend to handle my own affairs and break through the glass ceiling and all that, but it's good to have backup. And Ted is competent. When he says "hmm," things tend to happen. Excitement. Turn-on.

"What are you thinking, Teddy?"

"We're just about ready to test our replicator on something with a little more structure than a stainless steel fork. I think something organic is next."

"Yeah?" I'd worked on the nanotech replicator two semesters ago—mostly on the software to extract the molecular structure from non-destructive scanning with soft X-rays. The "conga line" of molecular placers was only a few million atoms long then, and not working very well. I'd kind of tried to keep up with it, but when Ted and I were together, there were, well, other matters to occupy our time.

"Maybe we could arrange a demonstration—show that even organic things, anyway, are entirely determined by where their atoms are. Drive another nail in the coffin of vitalism, so to speak."

"Could you replicate a mouse?"

"Yeah, I think so. But we'd have to freeze it first. That would get the fuzzy mafia all over us and besides, what would it prove?"

"What if the duplicate mouse remembered what its original knew?"

"Hmm, Kay, you're bright. Hadn't thought of that one. Actually, I was thinking something else . . ."

Terri Maraschino came by just then, a petite girl with big blue eyes and golden locks down to her ass.

"Hi, guys," she said, raising an eyebrow at me. "Doc Andre's got your number, Kay, huh?"

Lloyd College only has about thirteen

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hundred students and word gets around fast.

"It's nothing. I just made a sign-up day mistake and I'll get my C, get out of there and go on with my life."

"Gotta watch the GPA, kid. Sometimes, you know, you just gotta go with the flow, Kay. Give 'em what they want. Then they give back. He's not so bad, off duty, so to speak."

"Oh?" Teddy said, tensing. Why would he care? I mean, sure, he dated Terri occasionally, but so did the whole world. He couldn't be jealous about her; it would be like being jealous about air.

"Not too." Terri shrugged her shoulders.

"He's got a little surprise coming," Ted said with a grin.

I had no idea of what kind of surprise, but when Ted grins like that, good things happen.

"Oh?" Terri asked with maybe feigned indifference.

"Yeah. Kay, can you come by the lab tomorrow evening, about ten?"

I looked at Terri and grinned. "Sure, Ted."

When I met Ted in the lab, he had two dishes of lime Jello waiting.

"Lime Jello for dinner? You're weird, Teddy. Nice, but weird."

He gave me a spoon. "Taste one and then the other."

I got it, and did so. They both tasted like lime Jello.

"We made one of these the usual way in about ten minutes. The other took ten hours and most of the big Opticor as well as all of our homemade parallel processor. Can you tell which is which?"

I savored the Jellos again. They both had a fruity bouquet and a cool and rubbery start with just a little citric bite. Then syrupy sweetness melted in my mouth and slid down my throat. Damn it, they must have used real sugar. I pulled my stomach in, as if that would make any difference.

I shook my head in wonderment. "Can't tell the difference."

Ted grinned. "The replicated Jello is on the blue-bordered plate."

"Herr Doktor Professor Andre Stevens would, of course, claim there is some kind of ineffable difference to be elucidated by direct experience," I said.

"Let's call him on it."

"How would anyone get *him* to do a Jello taste test? Especially if he knew why? He's like any one of these hypocritical creeps with a made-up dogma—the last thing in the world he'd go for is an objective test of it. Teddy, we'd have to trick him, somehow."

Ted grinned. "Hmm. We could catch him in the cafeteria line. I know someone who works there—he could serve it to him—then we show up with cameras and say 'surprise!'"

"But he'd have to take the Jello, he'd have to eat it where we could get at him and he usually eats in the faculty lounge and we'd have to prove the Jello was replicated, and if we do it with Jello everyone's going to just laugh."

"I see. The Jello test is an interesting problem, but off target?"

"Yeah." It came to me just then what we had to duplicate. But it would be risky, risky as hell—not to mention illegal. "To prove it to him, we gotta get him where he lives," I said.

"Yeah. Hmm."

The look in Ted's eyes told me we'd had the same thought. I waited expectantly, hopefully. It would be a lot better if this were Ted's idea.

"It's complicated, but . . . do you know where he keeps his Stradivarius?"

That's my Ted.

So there we were lying in the snow below Stevens' office window on a moonless night with the stars shining down about as bright as they ever do in the middle of a two-million-person megalopolis, our skin-tight "moon colony" suits turned white as the snow to help keep our heat in with a black

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bag hidden under Ted. They were high-tech smart fabric and super-insulated but it was one of those Minnesota January nights where the difference between Fahrenheit and Celsius starts to look academic. I was literally shaking in my boots.

As soon as the campus patrol car finished snow-crunching through the parking lot and headed toward the Broiler, we got up out of the snow and dusted ourselves off. While I admired my snow angel, Ted held his watch face up at the window and pressed a stud. We waited and shook.

Earlier, he'd put on a maintenance uniform and stuck a remote-control bypass on the window crank motor—if the departmental admin support person had recognized him, she'd said nothing. Several students moonlighted in maintenance, so it was likely no big deal. He spent some time in the other offices too, for cover.

I'd unlocked the window today just before closing. I'd brought Stevens a cup of coffee on my way to plead for my grade, and he'd taken it. The coffee, not the plea. A couple of minutes later, when he excused himself to the bathroom, I'd flipped the latch up. We hoped he'd not noticed.

He hadn't. The window cranked itself open smoothly.

The rope ladder caught on the second try, and up we scurried.

"Less than three minutes," Ted said, obviously pleased. "Now, where's the violin?"

The best-laid plans ...

Fast forward to the last Saturday of spring break after a twelve-inch snowstorm. As a certified science nerd, I know why global warming means more snow and occasional cold records, too, but I still wonder at the paradox. Anyway, there'd been a concert that night at which Stevens had played, and we hoped against hope that, this time, he'd left the violin in his office. It was our seventh try.

I had not, however, made seven more appointments to see Stevens about my grades—even he would have suspected something was up if I'd done that. Fortunately, that had been unnecessary.

Now I know I could never sell this as fiction because no editor would believe that Stevens never checked the lock on his window for over two months. But that's knowing neither Stevens, who opens his office to fresh air about as often as he opens his mind to fresh ideas, nor Minnesota winters. Anyway, we checked with the remote every day before our attempts, and the window always opened.

The last fourteen weeks had been Chinese water torture, but we'd gotten into a routine and it had become sort of part of our lives. Nothing like a dose of repetitive failure to keep your feet on the ground—as if I needed anything more than my first-semester grades. But maybe the delay was a good thing—in the meantime they'd made some improvements to the scanner.

We had faculty help, of course. Hard science people are a minority at Lloyd who often have to eat it off the academic Trivium, and Stevens' attitude wasn't that popular with them. It was unpopular in particular with Dr. Gustaf Molar—a fitting name for a chemist, I thought, and another reason you know this isn't fiction. Anyway, he had time on the replicator for designer molecule work, and was kind enough to front for Ted's experiment—billed as an effort to demonstrate assembly of complex objects.

But when we told him how much time we needed, though, he was taken aback, and asked, "What is it? That's huge—I hope it's not someone's cat!"

"It's a violin," Ted told him.

I watched Dr. Molar's face frown, then break into a grin. I think he realized just then *whose* violin would get duplicated and why.

"You know," he said, "Democritus told us it was all just atoms. Two and a half millennia ago he'd figured out more

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than some people today will ever concede! Eliminating the fairies gave him a such a sense of inner peace that his contemporaries called him the laughing philosopher. So, yes, reproducing a so-called unique violin would be an appropriate jest. Quite appropriate." He laughed a little himself. "Yes, a very good joke—and *if* you don't make any bad mistakes, I don't think there will be too much retribution. The whole college knows *that* particular balloon needs to be pricked. But, of course, you will be very careful, and very discreet about my role in this?"

We'd both nodded.

Tonight, under cover of the blizzard, we didn't even have to lie in the snow. Everything went like clockwork. We had the violin in the scanner by midnight and back in Stevens' office by two A.M. And there was all day Sunday for the puddles of melted snow our boots left in his office to dry out.

Dr. Molar got us time on the replicator the first weekend in May. With exams and papers being written, there wasn't much demand. We started at eight P.M. Friday evening, and took shifts. I know Ted saw Terri on his first off-shift because I smelled her perfume when he got back at five Sunday morning. One of those pheromone things, and they work because I got excited secondhand. When the scanner is just sitting there going ka-chunk, ka-chunk, there's not much else to do.

But E. M. Forster was running things that night—like in his story, the machine we depended on stopped. There was a little, tinny, *thwack* and a pleasantly synthesized woman's voice announced that the program had terminated due to error code seven-thirty-two.

It broke the mood, kind of. I disengaged from Ted and went over to take a look in the reconstruction tube. There, encased in a block of clear matrix to be dissolved later, was a half-finished violin, done just about to the bridge. Except the matrix wasn't completely clear anymore. There were cracks. "Teddy, there's something wrong with the violin."

"Huh?" He got up, pulled his pants on and came over to inspect the repro. "What's code 732?"

"That," the system answered, "is for motion detected on the reconstruction stage by an accelerometer."

"Motion?" he asked. "Crap. The tension. It's unstable."

I realized what we were seeing. "The strings. We should have taken them off first."

"Yeah, they're under tension. As the rendering plane moves up, the strings get longer and just a little slippage anywhere along the string before they're complete . . . cascade . . . the matrix couldn't hold it any more."

I was silent for a bit. So near. Now we had to go through it all over again, maybe into next year! It had taken us fourteen weeks to get the Stradivarius long enough to replicate this time. We didn't have another fourteen weeks in the school year. Hell, we didn't have another fourteen *days*. I was furious and thought that way, coming up with nothing, of course.

"Maybe we could just continue and restring the replica." Ted said. But he didn't say "hmm" first, so I knew there had to be something wrong with that. It didn't take me long.

"It moved, Ted—that's why the program stopped. There was an acceleration. I don't care if it just moved a couple of nanometers—we'd end up with two halves of a Stradivarius."

He smiled and winced at once. "You're one bright lady, Kay. But just this once I wish you were wrong. I wish I could just reach into that scan pattern and . . . hmm."

"What, Ted? What is it?"

"If we rotate a virtual imaging plane so it's parallel with the strings—let's see, they bend at the bridge so there's eight string segments to worry about, but we could get two segments in each plane

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so that's four planes, maybe a few million molecules thick . . . If we make a software tool to erase just that part of those few million sections . . ."

He was going to do just that—reach in, and, in virtual reality, take the strings out of the pattern—*then* replicate what was left. "Wow, Ted, will it let you do that?"

"Let's ask it."

After half a day of very sophisticated machine-language persuasion, it let us, and we got going again on the broken-string violin about two Sunday morning. But now we were really short of time. At normal speed, it wouldn't finish until noon Monday and the lab would be full of students and it would be impossible to keep a secret. And it *had* to be kept secret.

"Any ideas?"

"I'm too tired, Kay."

I put a hand on his shoulder and sighed. "Me too. Maybe next year." If I had a next year.

"Hmm. Kay, why don't we just tell the truth? We're replicating a violin."

"But that would give it all away . . . oh!"

"Nobody's going to know *what* violin is in that tank. We'll just have some practice violin lying around and everyone will think *that* was the scan object."

Where would we get that? "I hate to say this; it's like a breach of security, but we need someone with a violin and an extra set of strings to put on the replica when it comes out."

"Terri plays the violin. And she's got a 1789 Figer—not a Stradivarius, but it looks old."

I had to ask, didn't I? The thought of her playing the Mendelssohn violin concerto made me want to puke. Couldn't she leave any of my men alone? "Don't you know someone else? Any old fiddle will probably do."

"You can trust Terri."

He grinned at me, the jerk. I groaned.

"She'll help us; I know she will."

"You know she will? Ted, what did you tell her?"

"I didn't tell her everything, but I had to break a date."

I felt like a hundred-meter-long lobster had seized my stomach with his claw. Terri's pillow talk is legendary. I kept my cool, oh yes. But I think I might have had some tears in my eyes, then.

He melted and put an arm around me, "Sure, Kay, sure. All I want from Terri right now is a violin and a tuning. She's just a violin object, okay?"

"A violin object. Right." Somehow I nodded.

Two hours later, Terri looked at the stringless violin in the block of plastic matrix and laughed. "First, you don't just restring a violin like this. The bridge will fall down as soon as you wash that stuff off, and then the sound post will probably move."

"Fall down?" Ted said.

"Sound post?" I chimed in.

Terri held her instrument up with a superior smile on her face. "Look inside, through the F-holes. See that wood dowel standing between the front and back? The tone of the violin depends on that being in just the right place and it's *not* glued. It just sits there, held in place by the pressure the strings put on the bridge above it. You need a special tool to get it back in place and hours of fiddling around with it. And the bridge has to be put up at exactly the right angle too, or the violin won't sound the same."

"It hasn't moved yet," I observed.

"But I can't restring it inside *that* stuff." Terri folded her arms and raised her eyebrows.

"Suppose," Ted said, "I just wash the stuff off the top. You could restring it and set the bridge up, then I'll wash the rest out."

"What do you wash it with?" Terri asked. "Water would ruin it."

"It's not water—Dr. Molar designed something that turns the matrix into

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carbon dioxide, methane and something else. I forget what, but you just squirt the solvent over it and it vaporizes."

Terri took a deep breath. "Okay, Teddy. For you, I'll try it. But I don't think it will fool him."

It will if you keep your mouth shut, I thought. "We've got to try at this point," I said.

No, we didn't. I could give the whole thing up.

No, I couldn't.

Terri smiled at me. "It's going to take a while, Kay."

I wanted to tell Ted to wipe that silly grin off his face and smash the "1789 Figer" over its owner's head. But she was holding the violin and all the cards.

So I smiled back. "Okay. Gotta book. Thanks. See you." Outside it was dark, thank goodness. I didn't want anyone to see my face like that.

I buried myself in books Monday night while Terri and Ted took care of stringing the replicated violin, etc. Yeah, it was an abject surrender, but I had a final Wednesday and classes Tuesday. I had to sleep. Passion is one thing, the rest of your life is something else. Grades were the rest of my life. Ted would be loyal or not, but I had to book, *had* to.

That night, I dreamed of sleeping with Andre Stevens for a grade. He took what he wanted, then laughed at me when I asked for the grade and gave me an F. I was about to deck him when I realized his laugh was my computer telling me it was time to get up and get going.

I didn't recognize the woman looking back at me from the mirror. Three months of nonstop tension, climbing rope ladders in subzero cold, and all-nighters with nothing to eat and I looked like I was halfway to that dreaded thirty. A touch of frost in the hair and I could be a prof. Weight problem? What weight problem?

No time for breakfast, even. Throw something on, grab the books, lock the door, and head for campus. Head back. I'd forgotten the lights—fifty cents of electricity. Fifty cents a day was fifteen dollars a month—a good part of my disposable budget. And it was raining. I slogged back through the mud to turn them off, grabbed a raincoat, locked the door again and started trotting for Calculus class. There wouldn't, I realized, be time to see Ted and the violin replica. What kind of girlfriend, I thought, leaves her squeeze all day with another woman for a fifty-cent light bill?

On the other hand, with the violin project known, maybe I shouldn't be around. Let's make my being late a strategic decision to maintain the element of surprise. Strategic decision, hell, I thought as I pulled the door to Jobs Hall open. You forgot to turn the lights off.

By the time the week was over, I was headed for B's in everything but Music Appreciation, with an outside chance at an A in calculus. I'd even managed to get Ted for a night—Wednesday—and saw the violin. We talked and planned until two A.M.

A couple of days before the concert, I went downstairs in the science building to see Ted to tell him what happened, and I saw him and Terri making out down in the Physics lab assistant's room. So I said "'scuse me," and left. Ted had won the conference meet—damn near seventy meters, and he was getting his reward, I guess. That giant lobster got hold of my gut again. I kind of collapsed on that little bench outside the room. I'd had such hopes and plans. Well, we still had the project. We could at least finish that together.

They came out a little later and Terri waved a cheery goodbye, leaving me with Ted. He came over. I looked up into his eyes. He pulled me up and put his arms around me while I got a little wet-eyed but I clamped down on the cry. I wasn't going to fall that low.

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"Kay, Kay," he murmured. "I wish I could be two people."

I thought of knocking him out and of using the replicator. I really did. Terri could have one Ted, and I'd have the other.

"Just give me a little room," my Ted said. "I need to sort this out. I still like you. I like you a lot. You're bright, you're competent. I'm just fighting my chemistry."

I just looked up at him and did something really stupid. "Ted," I said. "*I* love you—and *she* can't give you that." It was the first time either of us had ever said that word and it was most definitely uncool. But, again, I was feeling a little desperate. Terri just didn't *deserve* someone like Ted—she deserved a *real* jock, the dumb kind.

"Gee, I wish you hadn't said that, Kay."

"Yeah, me too. But there it is. Deal with it."

The last concert was Friday night. Stevens would take the violin home to practice Wednesday and Thursday night, so our only chance to switch the violins was Tuesday night. Ted gave me the violin and the remote Tuesday, between my calc final and the final torture session in Stevens' class.

"Can you handle this alone?" he asked. "I've got other plans."

I could figure that one out. But I wasn't going to give up now. "No sweat," I said in my best competent, liberated tone of voice. "I have the drill down cold."

He smiled and looked a little guilty.

We taped a cardboard box into some semblance of a violin case, and soon I was trotting off down the quad with a stolen Stradivarius.

Except it wasn't a real Stradivarius. Or was it? How could one tell? And what was its value? I had a sudden glimpse of a future in which our little escapade would not be seen as a harmless student prank. There was a lot of money tied up in things that were supposedly unique. Maybe my folks should have named me Pandora.

In Minnesota, on daylight savings time, within a month of the longest day of the year, it stays light pretty late. I waited in an open practice room—they should have kicked me out, I guess, but no one did. Besides the practice stool, it had a nice comfortable chair. So, yup, with all the stress and lost sleep and everything I was out cold by the time my rear end got comfortable.

It was twilight when I woke up. I snuck out under the gray, got below the window and opened my bag, partly hidden by the bushes. It was still pretty light, I thought—better wait a little while longer. Then I noticed something funny—it was light in the wrong part of the sky.

I looked at my watch. 4:50 A.M. A jogger ran by and waved at me. No way was I going to cat-burgle this morning—Stevens' office window faced east. I sat down in the grass and pounded my head and cried. The whole thing was over. One screw-up, and it was all over.

Determined to get the bad news over with and deal with it, I found Ted.

"I didn't make the switch," I said. "I fell asleep waiting for the coast to clear."

"Oh, oh." Ted said. He looked as miserable as I felt. "Then you've still got our replica?"

I nodded, miserably. I was deep into self-loathing. I thought about how to end it all—it wasn't cold enough out to freeze anymore, but the Mississippi was just a few blocks away, and the fall from the Lake Street bridge would probably stun me enough to let me drown in peace.

"Hmm," Ted said. "Maybe it doesn't matter. If the violins are identical, atom for atom, there would be no way to prove that one you have isn't *his* violin. You could just go on with the plan as if you had made the switch."

I shook my head. "He'd just say I was lying. How could I prove otherwise? I

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should have taken archeology. Then I could go on a field trip down to the Yucatan and sift for shards of some ancient cannibal's chamber pot while being eaten alive by AIDS-bearing mosquitoes."

But even when I'm emoting nonsense, Ted's a stickler for accuracy—an engineering disease, they say. "I don't think," he said, "there were cannibals in the Yucatan, I've never heard of them using chamber pots, and I don't think you can get AIDS from mosquitoes. Malaria, maybe."

"That's not the point!" I said.

Ted smiled—he knew, he was just trying to break the tension a little.

My mind ran open-loop. In the middle of this disaster, I imagined myself in the Central American jungle up to my knees in chamber pot shards, trying to figure out what pot they belonged to and how old they were.

How old? A thin ray of light pierced my gloom, a faint twinkling candle of hope a million miles away.

"Ted," I said slowly, "how would you date a chamber pot, anyway?"

I looked at Ted—and suddenly his smile changed to a big grin.

"Kay, you'll want to see Dr. Molar and tell him what's happened. And then you'll need to talk to Stephen's insurance company. We'll need a witness and certification."

Stephen's, it turned out, had insured his violin through Lloyd's of London, appropriately enough. And yes, they would be *very* interested in proof of which violin was the "real" Stradivarius. So interested that the fact that there was only a week until the concert was *no* problem.

That evening before the concert, I put on my one long black dress, grabbed my "good" black jacket and headed for the physics building, just a short walk from the concert hall. Ted was there with the Replica. He gave me a kiss and we headed for the fine arts center.

We caught up with Terri in the foyer. She was was in a tight all-black pants suit with a turtleneck collar.

"Hi," I said. "I'm going to sit up front to give him the replica to try."

She got the strangest expression I've ever seen on her face. "But doesn't he already *have* the replica?"

"I didn't make the switch. Fell asleep."

Terri looked first at me then Ted, looking for everything like a cornered rat. "Oh," she said.

The first few notes of "Dear Old Lloyd's" sounded on the PA chimes and we headed for our seats.

The concert was beautiful despite the character of the performer. For an encore, Stevens took the violin to the podium and played his own arrangement of "All Through the Night" with soft voices in the background sounding like an organ. There was hardly a dry eye in the house, including mine. I felt just awful. I knew, right then, that this was the wrong time, wrong place, wrong situation. It would just have to wait until next year. I'd planned to run up and spring the replica on him before the applause stopped. But I shut my eyes and stayed right where I was.

"You have something for me, Ms. Kim, I believe," Stevens announced, in front of everyone.

The lobster got my stomach and and grabbed hard. All of a sudden Terri's expression made sense; Stephens knew, and there was only one person who could have told him. I shot a look back at her that would vaporize an elephant. She kind of shrugged her shoulders.

"Ms. Kim, and some of her deconstructionist pranksters," Stevens continued, "have thought to play a little joke on me, and you. They made, with their little atomistic reductionist gizmo over in the physics building, an alleged *copy* of my Stradivarius violin. Now, the violin you heard tonight was quite adequate, surprisingly so, I must admit, or we would have had *this* conversation a little earlier. So, in fact, I am quite impressed. But the fun is over, Ms. Kim, and I would

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like my violin back, for this is not, as you all will soon hear, a real Stradivarius. Let's have it back now."

I desperately wanted to bail out of the whole thing. But it was much too late. I took the replica out of its tacky cardboard box and with as much poise as I could manage went up onto the stage. If you're going to go down, I told myself, go down in style.

"Well?" he intoned.

"I didn't make the switch," I said, hoping my voice didn't waver too much. "I'm carrying the replica."

"Nonsense. Young lady, this has gone far enough. That violin is worth over a million dollars, and you must return it this instant!"

I scanned the audience for Dr. Molar. He was the only one that could verify that I was telling the truth, but I couldn't find him. Had the analysis gone wrong? My hands got sweaty.

I turned back to Stevens. "But . . . but you've got it wrong. This isn't . . ."

"I do *not* have it wrong. This is not a Stradivarius." In anger he raised his violin by by its neck over his head, threatening to smash it down on the very solid-looking conductor's music stand.

Suddenly, I realized he really *could* destroy it, destroy the original Stradivarius, destroy something made so carefully from ancient wood by the long-dead master. My arms shot out toward him with the replica. "No! No! Don't break it. Here, take this then."

He frowned down on me and brought the violin down, but not on anything. Then he gave it to me. "So maybe I have taught you something after all. You would not see a beautiful instrument destroyed, even if it *wasn't* a Stradivarius. Very well. But now, you have to hear the difference," he beamed to the crowd, his voice and face full of confidence and triumph, "you and any curious folk who might wish to stay."

No one, absolutely no one, had left. My public humiliation was to be about as public as it could get. He turned to me. "You," he said ominously, but then smiled, "may sit down now."

The audience burst into laughter as I negotiated my way back across the stage. Why I didn't just run home, I don't know. Pride, I guess. Or maybe a death wish. At any rate, on my way back to my seat I saw Terri and Ted. Terri was laughing with everyone else. But Ted was sitting very quiet, with that "hmm" look on his face.

Stevens started tuning the replica. He frowned. Then he tuned it a little longer. It took a while, but finally he seemed satisfied.

The replica violin's performance of "All Through the Night" was, if anything, better. Stevens, subconsciously, no doubt, probably put more feeling into it. Or perhaps the tuning was slightly more fresh. At any rate, he proved my point exactly—but Ted, Terri and I were the *only* ones in the hall who knew it.

"I hope," Stevens said, "the superiority of the real instrument is obvious and the stupidity . . ."

"*Dr. Stevens*," a deep bass voice echoed from the back of the hall. A hundred heads turned. It was Professor Molar standing there backlit like the stone statue in Don Giovanni, and with, I hoped, a similar purpose. I wilted in relief. "Stevens, a moment please."

Stevens, interrupted in his moment of triumph, looked down his nose. "What do *you* want?"

"Privately, please, before you say anything else."

"*Nonsense!* This is my concert and I'll damn well say what I please!"

You could have heard a pin drop.

"Very well," Molar said, calmly. "Have you ever heard of carbon-14 dating?"

A few whispers started.

"What?" Stevens said. "Of course I have! What of it?"

"The violin you hold in your hand is less than fifty years old. Perhaps as new as yesterday."

There were a few nervous chuckles.

"*Nonsense!*"

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"I did the test myself. The one you described as the real Stradivarius is, in fact, the replica."

Titters began in the back and rolled forward to the stage in a wave of mirth.

Stevens looked at one violin, then the other, opened his mouth, shut it, then abruptly set the replica down, picked up the real Stradivarius, and held it for a long time. Then he laid it down again and shuffled out a side entrance. Some said there were tears in his eyes. The laughs died and the audience sat in shocked silence.

I went back up to the stage and took the new violin the old laughing philosopher had given me, and simply flowed down off the stage. The first claps started as I got halfway up the aisle and by the time I reached the back of the hall, I had to turn and wave. Ted was standing, leading the applause. Terri was nowhere to be seen. Ah, sweet, sweet vindication!

Just to tie this off, the "Democritus Violin," as they're calling our replica—it's quite famous now—was deemed property of the college and is on display in the science building. The debate still rages as to whether it is a real Stradivarius, but we've been enjoined from making any more replicas until some legal dust settles.

Professor Molar, it turned out, was late to the concert because of a long meeting with the College President and Dean of the faculty. Dr. Molar had done more than analyze the violin. He'd compiled a list of grievances from over a hundred students and faculty. Andre Stevens didn't like people disagreeing with his views, it seemed, and expressed his dislike in grades, recommendations and various other ways. There are advantages to being a private, rather than a state institution, and Dear Old Lloyd released Stevens from his contract in time for the disgraced musicologist to take an appointment at Twin Cities A&I for the next semester. He conceded nothing in a bitter final letter to the school newspaper saying that as his talents had declined to the point where he could no longer tell a real Stradivarius from a copy, he would never play again.

While Stevens' promise of an "A" for proving him wrong was not considered an enforceable contract, I was allowed to withdraw, post facto, from his course, and as a result, my grade point was high enough for my scholarship to be renewed—with some help from the athletic department. My penance for all of this will be to throw an aluminum disk as far as I can for the Women of Harlech next spring. A small price to pay; and, in partial compensation, I now have exclusive possession of Ted.

But I carry a secret with me. There was an ambiguity in my victory that makes me fear that Stevens may have won after all, if only in my own mind. When he was about to smash the original Stradivarius, I stopped him.

Now why, if the replica was no different, did I do that? ■

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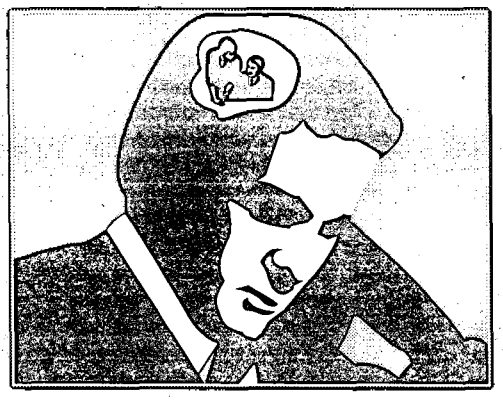
Kent Johnson

THE COMPANY MAN

Dedication is an admirable thing—up to a point!



As days go, Dean Plummer's was quickly moving from bad to something much, much worse. The morning—which had begun on a ominous note when he'd awakened to find a "system overload" symbol blinking behind his eyelids—was coming apart like wet tissue in a wind tunnel. First Albert Nguyen had sent an encrypted message from Orbital Colony Omega informing him that the packaging materials for the Sonic Blender, Dean's current project, might not meet Solar City's stringent specs, thus making the appliance unsuitable for sale in the mega-retailer's many offworld stores. Then Tracy Johnson beamed in from LA with the unsettling news that the Sonic Blender advertising blips Dean had approved had failed miserably in front of three separate test audiences, and could he please look at some more? And now Ronald, his personal assistant, secretary, and AI interface, was making soft, urgent sounds inside his head.

Kathy Innes is on the secure channel, he whispered. *Something about the SB Project. She says it's important.*

Dean considered relaying the call to Erin Barton-Higgins, his assistant director of marketing, then decided against it. He'd been delegating too much of his work to Barton-Higgins of late, and he knew that sooner or later the powers-

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that-be would catch on—that is, if they hadn't already.

"Kathy!" Dean exclaimed as Innes' pale countenance formed across his field of vision; a cramped, cluttered, orbital test lab was visible behind her. "Talk to me!"

"The seals failed again," Innes said grimly. "I dunno why, but as soon as we get the prototype up here in zero-g and run it on high speed for a few seconds, the seals start oozing like crazy..."

Great, Dean thought, *just what I need right now.*

"Any ideas?"

Innes shook her head. "It's a mystery to me. Marc Gorishek said it ran fine in the Mexico City lab—fully loaded and in standard gravity—so it should work up here."

"Christ," Dean said. "We can't afford any screwups tomorrow when we run that thing for Louie Wong..."

The pained look on Innes' pallid face said that she knew full well what was at stake here. "We could always send it back to engineering and have them redesign the seals."

"How long would that take?"

She shrugged. "You're the boss, you tell me."

"Hold on," Dean said. He blanked his internal vidscreen and Innes vanished. He called up his workstation, a greyscale template filled with pull-down menus, smartkeys, linkdots and several rows of application icons. He selected the icon labeled "Product engineering, timetables" and was immediately presented with a message stating INSUFFICIENT CIRCUIT CAPACITY, PLEASE TRY AGAIN LATER.

"Shit," he muttered, and brought Kathy Innes back on-line.

"Well," she asked. "What do you want me to do?"

Dean hesitated. He suddenly felt trapped, cornered, like an astronaut caught in a black hole gravity well. In his thirty-seven years, he'd rarely experienced the common human feelings of indecision, inadequacy, and self-doubt.

He was feeling them now...

"Keep working on it," he told Innes. "I'll talk to one of the staff engineers and get back to you."

"But what ab—"

Dean broke the connection, cutting her off in midsentence. With a heavy sigh he rose up from his polished mahogany desk and crossed the ten feet of grey broadloom to the room's only window, a floor-to-ceiling rectangle of polarized glass; even through the filter the sun was warm and welcome on his face.

Gotta get away when this one's over, he told himself, even though he knew that he wouldn't, that there was another project waiting on the heels of this one, and another after that. Even now, as he stood there gazing out across the Manhattan landscape from his penthouse office/apartment, levels of his mind below his consciousness were laying the groundwork for the next project, sifting and collating raw data: consumer surveys, production costs, distribution networks, advertising spreads and a host of other data that he as yet had only a cursory knowledge of. Dean had never had adequate words to describe the sensation, but a similarly-enhanced colleague had summed it up the best when she'd compared it to having a whitewater rapids raging through her head from ear to ear while she bobbed on the surface in an oarless rubber raft.

Sub-CEO Virgo requesting access, said Ronald.

"Great," Dean muttered. Returning to his desk, he sat down and closed his eyes. "Put him through."

He experienced the usual disorientation as his internal software patched his visual cortex directly into the VRnet. All at once he was standing in an office that wasn't an office, staring at a man who wasn't a man. As director of Martin-Matsuura's consumer products group, sub-CEO Virgo was in charge of the division's hundreds of human workers, thousands of computers and assembly

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robots, and dozens of mid-and-upper-level managers.

He was also one hundred percent computer AI.

"Hello, Virgo," Dean said.

The AI nodded and gave a stiff parody of a smile. Appearing in human form strictly for the benefit of the company's human component, Virgo was always dressed in the same perfectly tailored grey suit, imported silk shirt, and glistening black oxfords. Only the color of the carnation is his lapel changed from day to day. Today the flower glowed a dull crimson.

"Dean, is there a problem with the Sonic Blender project?" asked Virgo without preamble.

"Well, ah ... not really ... nothing serious."

"There have been rumors. Our stock fell six and a half points when the market opened this morning, although it has rallied in the last hour." Virgo's gaze seemed more probing than usual, and Dean found himself shifting uncomfortably in his chair. "You'd inform me if there were a problem, wouldn't you?"

Dean nodded. "Of course."

"The stockholders don't like surprises," the CEO continued. "As you know, the SB Project is important to the growth of the company. Having our products sold in the Solar City stores gives us a tremendous position in the burgeoning offworld markets."

Dean had heard this spiel—in several variations—at least a dozen times.

"We'll get the contract, don't worry," Dean assured him. "The only competition is that clunky contraption that StarBeam put together, and from what I've heard they've had so many design problems I don't think they'll even have a working prototype by tomorrow."

Virgo nodded solemnly, then abruptly changed the subject. "Our records show that you've been referring a large amount of your work to Ms. Barton-Higgins. Have you been experiencing any ... difficulties?"

Dean almost said, *Hell yes, I've been experiencing goddamn difficulties for some time, thank you, and I need that goddamn upgrade you pretentious bastards promised me more than three months ago....*

Instead he smiled and said, "One thing they taught us in business school is that a good manager has to know when and where to delegate."

Sub-CEO Virgo seemed less than satisfied with this response. "Then you should also know, Dean, that an effective manager has to make prompt and intelligent decisions."

"I've always delivered in the past, haven't I?" Dean felt himself getting defensive, and he didn't like it. "Who got the Zero-*g* Toaster project off the ground? And what about the Hard Vacuum Vacuum Cleaner? And don't forget the ..."

Virgo held up his hand. "I'm well aware of your many contributions to this company, Dean. But business is business, and the shareholders have certain ... expectations."

"Of course. I understand the bottom line. And by the way, about that upgrade ..."

Virgo paused a moment, and if he hadn't known better, Dean would've sworn that the AI was pondering something.

"We can't afford to take you off-line at the moment," the sub-CEO said finally. "But we may be able to do something the next time you're between projects."

I'm never between projects, Dean thought, but kept his mouth shut. Virgo flashed his rigid smile and sniffed his carnation. The meeting was over....

Opening his eyes, Dean sat back and waited for his vision to clear. Outside, a pigeon that had taken up residence on the window ledge cooed and ruffled its feathers, and Dean wondered absently where Iago was. *Probably got eaten by a hawk or something.* He took a few deep breaths, rubbed his temples, and tried not to dwell on the day's unravel-

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ing. Things would work out all right, he was sure of it, just as he was sure that one day he'd own a controlling share of Martin-Matsuura stock and then he'd be in charge of those overbearing AIs that called the shots and pulled all the corporate strings. But until that day, he'd just have to suck it up and play the game by their rules.

Incoming vidphone call, said Ronald. *No identification.*

"What now," Dean groaned, and told Ronald to accept the call. When the vidphone activated and John Fegan's face appeared on the small LCD screen, Dean felt his mouth fall open.

"Christ on a stick," he whispered. "Is that you, Johnny?"

"It's me," said the other man with a grin. "Surprised?"

Surprised wasn't the word. Dean hadn't seen his old college buddy in many years, and he almost didn't recognize this grown, middle-aged man with the vanishing hairline and the crow's feet fanning out from his eyes.

"What are . . . where are . . . what the hell are you doing in New York?"

"I'm here on business," Fegan said. "Leavin' this afternoon. I thought I'd look you up and see if you wanted to get together for lunch or something."

Lunch was impossible. Dean had a thousand things to do today. His presentation for Louie Wong, Solar City's top buyer, was less than twenty-four hours away, the Sonic Blender Project was coming apart all around him, his internal logic circuits were overloaded and screaming for help, and at that moment a dull throbbing ache was working its way up his spine and into the base of his skull.

"Lunch sounds great," he said. "Where are you?"

Ten minutes later, with Ronald whispering urgent entreaties inside his head, Dean stepped into his private elevator and took the short ride up to his rooftop terrace. He was making his way around the pool to the helipad, the naked sun stabbing at his eyes, when he nearly tripped over the prostrate form of Iago, his artificial, solar-powered, pigeon-scaring owl.

At the moment the bird looked anything but scary as it lay face-down on the smooth Spanish tiles, its wings thrashing without effect, a land-bound swimmer doing the breast stroke.

"Christ," said Dean with a shake of his head. "You're about as useful as tits on a robot."

He scooped the owl up and set it on its roost overlooking the terrace; it regarded him with huge, vacant eyes, blinked slowly, and looked away.

Turning on his heels, Dean crossed over to the helipad, where his white Bell Tristar—a civilian version of the same helicopter that had distinguished itself in the East African Famine War—was already powering up its turbofan engines. As he approached—his head bowed against the prop wash from the spinning rotor blades—a door in the 'copter's flank slid open and he climbed inside.

The passenger cabin was cramped but comfortably furnished. Dean sank into one of the high-back leather seats along the window as the door closed behind him, sealing out much of the prop and engine noise. He poured a cup of mineral water from the drink dispenser at his elbow, drained it in a single gulp, then sat back and waited for the autopilot AI to complete its preflight checklist.

"Destination?" A toneless voice asked a few moments later.

"The Seiko Tower," Dean said.

There was a muted vibration as the turbofans throttled up and then the usual belly-in-your-throat sensation as the Tristar lifted off the pad. They hovered a moment—waiting for clearance—then the 'copter's nose tipped forward and they accelerated into one of the westbound traffic lanes. Posh Upper East Side apartment buildings flashed by the

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window, monuments to the city's rich and mostly-enhanced elite. The 'copter rose and fell in the turbulent air. Dean gripped the armrest and was silently thankful that his internal medware had intervened before his headache could become a full-blown migraine.

Traffic was heavy this morning, and several times they had to make course corrections to avoid lumbering freight zeppelins and sleek hypersonic jetliners. Peering out the window, Dean caught sight of New York's other population: people of all races and types walking or 'blading the sidewalks or moving about the city in levs or the ubiquitous yellow taxis. Many of them seemed to be going about their business at a slow, unhurried pace, and not for the first time he found himself envying them, the way one might envy a dog or a cat lounging in blissful ignorance on the floor....

He was abruptly aware of several icons flashing in the periphery of his vision and of Ronald's harried voice coming to him via his small onyx earring/transceiver.

Dean, you have several callers holding.

He sighed. "Anything important?"

Tracy Johnson wants to know if you've picked out any new SB ad blips for her, Chris Grey is inquiring about that break-even analysis he sent you yesterday, and Kathy Innes is wondering what she should do about those seals and whether or not you've consulted anyone in the design department.

"Tell them all I'm at lunch and I'll get back to 'em this afternoon." Dean—used to being in control—felt his earlier indecisiveness beginning to recede. "Then get on the line and see if you can reach someone in Product Design, preferably Pat Hidalgo. If you get a hold of him, tell him it's urgent and patch him through right away. If it's anything else, I don't wanna hear about it until I'm done with my lunch, understood?"

Understood.

Ronald broke the connection, and Dean sat back and tried to think of what he'd say to John Fegan. *How ya doing, old buddy? Gee, you look great, how's the wife and kids? Do you have a wife and kids?* So much had happened since they'd last seen one another, so much water had passed beneath the proverbial bridge, that he didn't really know where to begin.

Glancing out the window, he saw that the 'copter was passing over the Central Park Biosphere. The giant fiberplas dome was scratched and pitted almost to the point of opaqueness, and even in the midday sun he could barely discern the lush mix of trees, ferns, and flowering plants that thrived in the biosphere's subtropical climate. A splash of color came into view as a delta-winged paraglider worked the roiling thermals rising up along the dome's curved inner surface. Dean felt that annoying stab of envy again as he wondering what it would be like to be in that glider, wheeling through the air like a feather, not a care or a worry in the world. *Time enough for that someday,* he reminded himself. *Stick to the plan, have patience, and one day I'll be rich enough to buy that whole goddamn biosphere and turn it into my personal playground if I want ...*

Just then a massive jetliner swept by in the opposite lane, sending the Tristar bouncing and rocking in its wake. Gripping the armrest, Dean sat back and closed his eyes.

The system overload symbol was still blinking.

Dean had grown up in a world in transition, a world that was busy remaking itself at almost every turn. Each new scientific or technological advance had seemed to spawn a hundred more, and then thousands, and on and on until even the engineers and scientists and Big Thinkers could barely make sense of it all. In time they turned to the new and

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powerful artificial intelligences to help them harness these emerging technologies, and soon AIs were directing research centers, controlling military complexes, and running vast multinational corporations. The global economy born in the twentieth century had gone transglobal as orbital colonies were constructed, Mars was settled, and the moons of several planets became home to miners, geologists, engineers, and gung-ho pioneers. Virtual reality—once little more than a high-tech toy—quickly evolved into the communication and information medium of choice, linking the billions of earthbound and offworld humans in a visceral way that old-fashioned television and telephones and fax machines never could. And with this new medium came commerce, and big business, and suddenly products could be developed and marketed and sold to the masses at lightning speeds. It soon became apparent that ordinary humans were poorly adapted to this rapidly changing environment, and so the AIs went to work on a new class of people, ones that spoke their language and shared their world ...

People like Dean Plummer.

Before he was even conceived, Dean's parents made the difficult and expensive decision to have him genetically and neurologically enhanced. The young, dour counsellor at the family planning center had assured them that only those children who were equipped to meet the demands of the future would excel in the coming century. Unenhanced, or "base" humans, as they were derisively referred to, were destined for mediocrity. They would be little more than human robots, relegated to menial jobs in food service or asteroid mining or other even more unsavory occupations. Not openly discriminated against, of course, but excluded from the best careers because of their, well, limitations. Corporate downsizing was all the rage, after all, and enhanced employees could learn twice as fast and do the work of two or three of their unenhanced counterparts. Dean's parents—both successful professionals—got the message.

And so the geneticists—with the help of the AIs and the knowledge gleaned from the Human Genome Project—tweaked Dean's DNA and RNA while he was little more than a loose collection of cells floating in a petri dish. Improved neurotransmitters were introduced, along with a network of organic microfiliments connected to a parallel biochip interface. Nanotechnology was used to alter the structure of his developing nervous system, allowing access to areas of the brain that went unused in base humans. A neural shunt was installed in his tiny skull, his future connection to a world of supercomputers, communications satellites, and the VRnet.

By the time baby Dean was finally taken off the umbilicals and he slipped coughing and screaming from his artificial womb, he had been, quite literally, hardwired for success.

"Dean, my God, how long's it been?"

"A long time."

Dean gave John Fegan's hand a firm, earnest shake, then drew out a chair and sat down opposite his old friend. It was just past twelve, and the cafe was thick with smoke and the din of business people engaging in lunchtime commerce. A harried-looking waiter appeared, took their drink order, and bustled off.

"You're having a beer?" Dean asked, surprised. Alcohol was known to interfere with the complex chemical processes at work in the brains of the Enhanced, and most of them avoided it—at least during office hours.

John Fegan grinned. "I don't have to worry about that anymore."

Dean gazed at him quizzically, and noticed for the first time that the other man didn't seem to be wearing a transceiver or any other type of linkup device. And he noticed something else: even though both men were approxi-

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mately the same age, Fegan seemed younger somehow—more at ease with himself—like a man coming off a long and thoroughly enjoyable vacation.

"Christ," said Dean. "What did you . . . what *happened*?"

Fegan's smile broadened. "I had it taken out, Dean. The entire system, interface and all. It took three operations and a shitload of money, but I did it."

"But why?"

"Because I was losing my fucking mind." Their drinks had arrived, and Fegan took a long, thoughtful draw on his beer. He licked foam off his lips and said, "I guess I just wasn't cut out for it. I mean I tried, you know, I really did. I know what my parents went through to buy me all that hardware. It took most of their retirement money, not to mention a second mortgage on their house. But I just couldn't fucking take it anymore."

"Wow," whispered Dean, although having one's implants removed wasn't unprecedented. He'd heard of small communities of formerly-enhanced people out in the rural areas, cults and religious movements, the rumors said, backward types bent on eschewing technology and living purely human lives. But he'd never known anyone who'd actually considered it.

Or if they had, they hadn't mentioned it to *him*.

"Don't look so shocked," Fegan said. "Lots of people are doing it. In fact, our entire staff at Concentric are unwired, all by choice."

"Concentric?" Dean was still puzzling over all this. "What's that?"

"We build custom homes." Fegan finished his beer and signaled to the waiter for another. "It's just a little startup company in Pennsylvania."

"Philly?"

Fegan shook his head. "Strasburg, in Lancaster County. It's Dutch Amish country."

Dean chuckled. "What'd you do, ride up here in one of those quaint, horse-drawn buggies?"

Fegan forced an irritated smile. "I came up on the maglev, Dean. I didn't say that *I* was Amish. We still use computers—they're just on our desks, not in our heads."

Dean sipped his mineral water and tried to make sense of what he was hearing. Having one's implants removed seemed so . . . unnatural. It went against everything he believed in, everything he'd learned in all his schools and interactive tutor sessions and everyday life experiences. It was a step backward in the order of things. De-evolution. After all, weren't people always striving to better themselves? Wasn't it some unwritten law of nature, ever since that first primate wrapped its curious fingers around a club?

"I still don't get it, John. I mean being wired can be a pain in the ass—I'll be the first one to admit it—but it still seems a lot better than the alternative."

"Not to me." Fegan made a dismissive gesture with his hand. "It just got so crazy there at the end. I was working for one of the construction companies that had been contracted to build the Trans-Atlantic Tube. I was a welding foreman, and I spent most of my time operating remote probes that inspected welds along the outside surface of the tube. If one of the probes detected a bad joint, I'd send down a robot to re-weld it. There were literally millions of these goddamn welds, and the smallest crack in any one of them could lead to a breach that would flood the tube and kill God only knows how many people.

"Anyway, there was a lot of time pressure on us because the job was running behind and over budget the stockholders where shitting bricks. Pretty soon I was running those probes—two or three at a time—virtually day and night. It was crazy. I'd be working around the house or playing games with my two daughters, and the other half of my mind would be on the bottom of the Atlantic, bouncing radar signals through three-inch steel plate. It got to where I

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was seeing welding arcs in my dreams. It nearly cost me my marriage—and my sanity."

Dean didn't know what to say. Despite the medware, his headache was returning with a vengeance. He noticed Ronald's icon flashing in the corner of his vision. He ignored it.

"Well, how about you?" Fegan asked, his face brightening. "I heard you're a player over at Martin-Matsuura."

"I'm director of marketing."

Fegan grimaced. "And working for an AI, I'll bet."

"Of course." He shrugged. "They're better than we are at a lot of things, you've gotta admit."

"Yeah, I guess. But don't you ever worry that they'll get so good they'll run you right out of a job?"

"Never happen," Dean said. He called up the lunch menu and tried to concentrate on the flickering green holo floating above the table. "They're smart, but they're still no good at creative things, they've got no intuition, and they don't have a clue about what people like or want. And remember, people still *own* the corporations, not AIs."

"For the moment." Fegan frowned and gazed into his beer. "I see all this interfacing of people and computers and sometimes I wonder where it's gonna end, you know?"

Their waiter returned, eyebrows raised. Dean ordered the glazed pork loin sandwich, Fegan the curried bay shrimp. The waiter nodded his approval and left.

"How'd you like to come work for me?" Fegan leaned forward on his elbows. "Concentric's growing, and we could use a good marketing man."

This pitch caught Dean off guard, and he blinked in surprise. "Whoa, John, what are we talking about here?"

"We're talking about director of marketing, for starters, with a progressive new company, in the country, working for real people instead of AIs. I think you'd love it."

Dean sighed. "I dunno, John. I've got a pretty good thing going at Matsuura: profit sharing, country club membership, my own expense account. Besides, I don't think I could give up my hardware—I don't think I'd *want* to. I like the rush of all that data streaming through my head—at least most of the time—and I'd probably go crazy with only my own thoughts to keep me company. I mean it sounds like this has been a good move for you and all, but I still believe that enhancements are the future of humanity. . . ."

Fegan nodded; he looked resigned, as if this was the answer he'd been expecting. He paused a moment, then said, "Once upon a time, machines were going to free men to lives of leisure. Do you feel free, Dean?"

Dean frowned and said nothing. The waiter arrived with their food, and they ate in silence for a time, both men lost in thought. Dean found himself contemplating the course of his life and the possibilities receding like a darkened road behind him. His head throbbed with every bite of his sandwich.

"No hard feelings?" he asked finally.

Fegan shrugged. "Not for me."

"Good."

Fegan sighed and pushed back from the table. "Hey, we'll have to do this again. I'll be back here on business from time to time."

"Yeah." Dean nodded. "Sure."

"And if you're ever out in Pennsylvania, look me up. Bring the wife and kids. Who knows, maybe I'll get you guys a ride in one of those horse-drawn buggies."

"I'm divorced."

Fegan frowned. "Sorry to hear that. Kids?"

Dean shook his head. "We never could quite fit kids into the picture. Maybe it's better that we didn't, the way things turned out." There was an awkward pause. "I've got a girlfriend. That's about all I can handle right now."

"Well, then bring *her* along."

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Dean smiled. "Yeah. Sure."

Back at his apartment, Dean found Ronald in a state of near panic, or as close to it as his personal assistant—in physical terms little more than a small cylinder of neural paste in one corner of Dean's office—was capable of.

Throughout Dean's lunch the calls had just kept coming, Ronald informed him, beginning with Marc Gorishek from the company's Mexico City plant. Apparently a glitch had developed in the Sonic Blender production line and Gorishek wasn't sure he could deliver the twenty thousand units that Solar City would want if they secured the contract. Then Tracy Johnson made another inquiry about those revised ads, Albert Nguyen beamed in wanting to know if he could show Dean a few redesigned blister packs, and Chris Grey left another message about that break-even analysis.

"Patch me through to Ms. Barton-Higgins," Dean said. "Then call Chris Grey and tell him I'm ready to transmit that analysis. And did you ever reach Pat Hidalgo?"

Negative. His assistant informed me that he'll be unavailable until later this afternoon.

Great, he thought. His internal vidscreen activated and Erin Barton-Higgins' implacable presence loomed before him like a stone god. He wasn't sure why, but he always felt a little uneasy around this earnest young woman. He couldn't remember ever seeing her smile, and he wondered not for the first time if she and her husband slept in separate bedrooms.

"Erin!" he said with forced exuberance. "How's it going?"

"You tell me."

He squinted. "What do you mean?"

"The Sonic Blender Project," she said. "I've heard rumors that there's a problem with the containment seals."

"Not really." In the corner of his eye, Dean saw the transmit symbol blink on as Chris Grey began to download the break-even analysis. "I've got the situation under control."

"Are you sure?"

"Of course." Dean shifted in his chair. "But I *could* use some help screening advertising blips. Do you think you could look at a few and get back to Tracy Johnson in L.A.?"

She looked less than pleased at having a new task added to her already-considerable workload, but she shrugged and said, "I'll take care of it."

"Thanks," Dean said. Despite Erin's rather stern personality, he still found her attractive, and sometime back he'd taken it upon himself to try and loosen her up, shake her out, take a sledgehammer to that tough-as-titanium exterior. "We'll have to do lunch when this one's over," he told her. "Catch up on things."

She gave him a slightly quizzical look that he wasn't familiar with, and for a moment he thought she was going to take him up on his offer. But then her usual expression returned and she said, "Is there anything else, Dean?"

"No. I'll see you tomorrow at the presentation."

Erin Barton-Higgins nodded and was gone.

Dean spent the remainder of the afternoon trying to catch up with his backlog of work. It was a daunting task, made even more difficult because of the constant memory and circuit conflicts he was experiencing. Operations that used to be a snap now seemed to take forever, and he found himself wondering if he wasn't beginning to lose it altogether.

That's how I felt before my last upgrade, he reminded himself. *And the one before that.* And he *had* had the same misgivings all those times, come to think of it, and suddenly he felt better about things. As Virgo had said, at the next opportunity they'd get him into surgery and stuff a few more high-tech goodies into his head. Soon this

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this would all be just an unpleasant memory....

At just past four o'clock, Ronald broke in and said that he'd finally tracked down Pat Hidalgo out on the back nine of the Rancho Hills golf course. Dean put him on screen. Martin-Matsuura's best design engineer looked less than thrilled at having his golf game interrupted, but Dean quickly explained the situation with the Sonic Blender's problematic seals. Hidalgo's response was less than encouraging.

"No way I could have anything for you by tomorrow," he said. Behind him, his partner teed off, did some creative body language as he watched the ball sail left of the fairway, then threw his club down and directed a scalding critique at the heavens. "I'd have to get a full report from Kathy Innes, inspect the prototype—preferably in zero-*g*—then see what I could do. We'd be looking at two to three days minimum."

"We don't have two or three days."

Hidalgo shrugged. "Then I guess we'll just have to hope we win the contract and then we can make the modifications in preproduction."

"But if the seals leak in front of Louie Wong, we won't *win* the goddamn contract."

Hidalgo gazed into the microcam lens and said nothing.

"Oh well, I'll think of something," Dean said. "Good luck with your game. I hope you're doing better than your partner."

"The gods are with me," said Hidalgo, and broke the connection.

Dean was just finishing a lengthy VR linkup with Albert Nguyen when Janis came home. Leaning over his chair, she kissed his forehead, his nose, his lips. He reached over, wrapped his arm around her waist, pulled her down into his lap. She giggled. She kissed him again, this time with feeling. Hands groped at zippers and shirt buttons. She was wearing one of those pheromone-activated perfumes, and the musky scent of her arousal filled his nostrils.

"Are you off duty?" she breathed into his ear.

"Yes." He sighed. "No. I just need to take care of a few more things."

She pulled back, frowning. "Boy, you really know how to spoil the moment."

"It'll only take a few more minutes."

She worked her lips into a pout. "Promise?"

"Promise."

"Oh, all right." She climbed off his lap and gave a few halfhearted tugs at her wrinkled skirt. "Maybe I'll go for a quick swim while I'm waiting."

"Great. I'll finish up here and then we can go out to dinner and catch a show or something."

As he watched her turn and walk away toward the bedroom, her scent clinging to him like a shroud, he suddenly found himself thinking of that brightly-colored paraglider he'd seen wheeling like a hawk through the Central Park Biodome. *Someday,* he promised himself. *Someday.*

Then he activated his VRnet interface and found himself moving through space of another kind.

Soft, urgent sounds.

The bedroom was dark except for a skylight-shaped patch of moonlight reflected on the wall. A few feet away, in the king-sized bed, Janis seemed to pulse with energy as she moved beneath him—soft, urgent sounds issuing from her mouth, her back arching in pleasure. Dean gripped her shoulders and tried to concentrate on the task at hand, but Ronald's icon kept blinking in the periphery of his vision. In an ironic twist of that old adage, he tried to think of sex instead of business in this fervid moment—and failed. He couldn't get that goddamn blender out of his mind, and its goddamn seals, and what was going to happen at that all-important meeting with Louie Wong in the morning.

Then all at once Ronald was whisper-

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ing in his ear. *I realize this is an awkward time, Dean, but—*

Awkward time? Dean subvocalized. *Get the hell out of here!*

I'm sorry, but it's Kathy Innes. She's on line two and she says it's important. She has *to speak to you right away.*

Dean nearly laughed out loud at the absurdity of the situation, especially in light of John Fegan's lunchtime diatribe about the indignities of human enhancements. He considered pawning Kathy Innes off on Erin, but knew that he couldn't. This was his problem, and he'd have to deal with it sooner or later. With an inward groan he told Ronald to put the call through.

"Want to switch positions?" he asked Janis. "Try it on top for awhile?"

She grinned playfully. "Why, are you running out of gas already?"

"Got a cramp," he lied.

She paused only a moment. "Yeah, OK, I'll do the work for awhile. . . ."

They performed the maneuver quickly, effortlessly, and before he knew it Dean was looking up into Janis' moonlit face, her long hair falling like a veil around them, trapping in their hot breath and the musky scent of their lovemaking.

Dean closed his eyes and activated his internal screen. Kathy Innes appeared before him, floating in her orbital test lab. She looked even more pale and anxious than she had earlier that morning.

"Kathy!" Dean subvocalized. "Did you come up with anything?"

"I was just about to ask you the same thing," she said acidly. "You were gonna get back to me, remember?"

"I talked to Pat Hidalgo over in design," Dean said, ignoring the comment. "He told me there's no way he could do anything by tomorrow morning. But I've got an idea . . ."

Innes peered at him through the lens. "I'm listening."

"You said before that the seals only leak when the blender's turned to the high speed setting."

She nodded.

"Well I was thinking. What if we don't *run* the blender on high speed when we do the presentation tomorrow."

Innes squinted. "But won't Mr. Wong want to see a full demonstration?"

"I doubt it. He won't be there in person, after all, he'll just holo up from New Hong Kong like he usually does. Besides, I know Louie. We've done business before. He'll just take a quick look at the prototype—kick the tires, so to speak—and then sign off on the contract. It's practically a done deal. Then we can fix the seals later, before they hit the assembly line."

Kathy Innes looked skeptical. "Are you sure about this, Mr. Plummer?"

"Trust me," said Dean. "Just let me do the talking, and we'll pull this off, you'll see."

Innes reluctantly agreed to the plan and hung up. Dean deactivated his screen, opened his eyes, and found himself blinking in pain. A light was on in the bedroom. Through squinted eyes he saw Janis—who'd been making passionate love to him only a few moments before—sitting on the edge of the bed. Already half-dressed, she was fingering the buttons of her blouse, her face turned away from him. He glanced down and saw that his penis was quickly softening into its post-erection slumber.

"What happened?"

"Oh, you're back." Her tone was terse, corrosive. "Well, I guess no one can accuse *you* of having a one-track mind."

"Christ, I'm sorry." He knew the apology sounded lame, but he went on anyway. "I just had to . . . take care of something."

"Well maybe you should take care of *me* once in awhile." Sweeping her hair out of her face, she turned to look at him. "And I'm not just talking about in bed. Two or three times at dinner tonight I said something to you and you had your eyes closed, that blank look on your face, like a zombie or something. I'm not some fucking bimbo you can

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just tune out whenever you want."

He sat up, pulled on his briefs and moved over beside her. "Janis, please. It's just this damn project I'm working on. It'll be over in a few days, I promise."

"Yeah, yeah." She rose and stepped into her boots. At the door she turned and said, "I've heard it all before, Dean. Too many times. You need to find someone who's wired just like you, someone you can interface with. Maybe a computer or something."

"Come on, that's not fair," he said, feeling awkward and confused.

But she'd already walked out the door.

In the morning, Dean flew over to Martin-Matsuura's midtown office tower and then he and Erin Barton-Higgins caught a supply shuttle up to Orbital Colony Beta. The two marketing execs rode in silence, both lost in their own thoughts as the shuttle burned through the upper ionosphere and into low Earth orbit. Peering out the forward porthole, Dean watched the intricate, torus-shaped colony grow in size as they approached. A lattice of spars and struts and solar arrays gradually resolved out of the darkness, and several spacesuited workers could been seen moving about as they attended to one of the station's giant microwave antennas.

This was only the fifth time Dean had been offplanet, and as always he found the experience somewhat disconcerting as the huge shadowed globe of the Earth loomed above them like the heel of God. As the shuttle slipped into the Colony's slowly-rotating hub, he glanced over at Erin, but she looked as stoic as ever, as if this were nothing more than a leisurely jaunt across Manhattan.

They were met in the airlock antechamber by Kathy Innes. The engineer seemed uneasy, and Dean noticed that she had trouble meeting his gaze as she gave him a brief, polite greeting.

They donned magnetic shoes and then followed Innes into a long cylindrical corridor with doors and access panels at all angles. Kicking off with the skill of a zero-*g* veteran, Innes led the way down the passage until they reached a door that opened onto a small conference room. There was a round table and a dozen or so chairs, a holo projection platform, and several wall-sized video screens. At the center of the table—displayed prominently and spotlit from above—was the Sonic Blender prototype.

"Where's Louie?" Dean asked. Both women shrugged as if to say "who knows?" Moving gingerly in the magnetic shoes, he half-jumped, half-floated over to the table; this was the first time he'd seen the prototype in person, and he was impressed by the unit's compact size and sleek appearance.

Just then the holo platform chimed softly and Louie Wong's image shimmered into existence. The late-middle-aged man looked drawn and tired, and not altogether happy about being present at this meeting. He swept his gaze around the room, finally stopping at the three Martin-Matsuura employees. "Dean, Ms. Barton-Higgins, Ms. Innes."

"Hello, Louie," Dean said. "Glad you could make it."

"It's my pleasure." Wong flashed a curt smile. "I don't mean to be abrupt, Dean, but I'd appreciate it if we could get right down to business."

Dean shrugged. "Yeah, sure."

"Good. Now let's hear about that blender of yours."

Dean smiled and launched into a prerecorded sales pitch that appeared word-for-word along the bottom of his vision. "Well, Louie, we here at Martin-Matsuura think we've designed the ultimate liquid blender for micro and zero-*g* environments."

He turned and gave the prototype an affectionate pat. "Instead of using rotating blades for mixing as in current blender designs—which don't work well in zero-*g*, by the way, because there's no gravity to pull the liquid into

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contact with the blades—our Sonic Blender uses ultrasonic sound waves for thorough blending no matter how the liquid is oriented in the mixing chamber. Milk shakes, vegetable drinks, smoothies, you name it, this baby can handle it. It's the ideal kitchen appliance for today's busy offworld colonist, and at this price I think it'll be a runaway best seller at all your Solar City stores."

Louie Wong took all this in without comment, and in fact he seemed to be examining his fingernails during Dean's short presentation. Finally he looked up and said, "Sounds like you've got a viable product, Dean. Can I see it in action?"

"Of course." Dean had been expecting this, and he reached out a finger and pressed the "low speed blend" button on the blender's control panel. The appliance hummed softly, and the brown liquid in its mixing chamber suddenly began to churn and vibrate as ultrasonic sound waves pulsed through it.

"Look at that action," Dean said proudly. "Works great, doesn't it, Louie?"

Wong didn't answer. After a moment he cleared his throat and said, "How does it perform on the high speed setting?"

Dean froze. "Ah, the high speed setting?"

Wong nodded. "I believe it's the button to the right of your finger."

Oh shit, Dean thought. *This wasn't supposed to happen. And why was Wong acting so strange? Had someone tipped him off to the seal problem?*

"Well?" Wong asked.

Dean's mind was racing. He felt beads of sweat prickle his forehead. Then Erin, who'd been standing quietly in the background, joined him at the table.

"It's this one," she said, stabbing a button on the blender. The humming sound rose in pitch. Horrified, Dean held his breath as he waited for the liquid to come oozing out of the mixing chamber's seals.

Nothing happened.

They stood there for two or three full minutes, but the blender performed flawlessly.

"All right," Wong said finally. "I've seen enough."

Dean exhaled with relief and switched off the blender. It only took him a moment to regain his composure.

"Well, what do you think, Louie? Is this one beautiful kitchen appliance or what?"

"I like it," Wong said. "In fact, I'd be willing to recommend it to my superiors right now. The only reservation I have concerns your company's impending labor dispute."

"Labor dispute?" Dean said stupidly.

"Yes. We've heard rumors that the union representing your distribution employees is considering a strike when the current contract expires later this year."

What the hell's he talking about? Dean was about to ask for a break to consult with Ronald when Erin spoke up again.

"That's all been taken care of, Mr. Wong. Our people have been negotiating with the union for the past few weeks, and we've worked out a tentative contract extension that both sides seem happy with."

Wong regarded her with raised eyebrows. "Very good," he said. "I'll pass that on to the Board. You'll have our decision shortly. And now, if you'll excuse me." He gave a quick bow and was gone.

Dean felt numb. For the first time in his career he'd been upstaged by a subordinate, and it had happened so suddenly he wasn't sure whether to be angry or pleased. He glanced at Erin, then at Kathy Innes. "Could one of you please fill me in here?"

"Fill you in?" Erin asked.

"Yeah," Dean said. "Like how come those goddamn seals didn't leak just now? Are they defective or not?"

"That was Erin's idea," Innes said sheepishly. "She had me rewire the high speed switch into the normal speed cir-

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cuit. Then we installed a piezo beeper that just made it *sound* like the blender was running faster."

"Well . . . OK," Dean said. "That was a good idea—although I wish someone had cleared it with me beforehand." He turned to Erin. "And what's all this about the labor union? How come I wasn't told about a possible strike?"

"You were," Erin said quietly. "The interoffice memo came down a few months ago. You passed it on to me, told me to look into it, remember?"

Dean didn't answer. His mind was reeling. "Yeah, OK. But don't go over my head like this again. It's embarrassing."

"I don't think that'll be a problem," Erin said.

"What's that supposed to mean?"

"I thought you knew." She seemed genuinely surprised. "I've been promoted. As of next week, I'll be the new director of marketing. . . ."

When Dean got back to his apartment, he sat down at his desk and immediately requested a VR link to sub-CEO Virgo's "office." He closed his eyes. There was a short pause, then the Martin-Matsuura logo was replaced by Virgo's precise, computer-generated image.

"Dean, good to see you!" Today the CEO's carnation glowed a pale blue. "Congratulations are in order! I've just received word that Solar City has agreed to carry our blenders in their offworld stores!"

"Great," Dean muttered. The shuttle ride down from orbit had been a tense half hour as a maelstrom of emotions had coursed through him, and even now he could feel his fingernails digging into the palms of his hands. "I hear you've got some *other* news for me."

"You must be referring to Ms. Barton-Higgins. . . ."

"Yeah, I hear she's getting my job."

Virgo frowned with mock sincerity. "Regrettably, we felt a change in management styles was in order. Nothing against you personally, of course, but Ms. Barton-Higgins has . . . outperformed you of late."

"Bullshit," Dean said, but without much conviction. He suddenly felt small and very tired. "It's because she's younger, isn't it?"

"She's younger," Virgo admitted, "and her implants are of a newer, more efficient design. Also, her brain was genetically engineered to be compatible with the latest quantum computer technology." He shrugged. "It's just the way of things, Dean."

"What about that upgrade you promised me? That's all I need, then things'll be like the old days, you'll see."

"I'm afraid that's the problem," Virgo said. "Our engineers have determined that an upgrade wouldn't do you much good. It seems your circuit architecture has become hopelessly outdated."

"Outdated?" Dean was incredulous. "What the hell are you talking about? My hardware was designed to be upgradable. I mean we've already done it, what, six or seven times?"

"The problem's at the genetic level," Virgo explained. "New hardware won't correct the situation. Face it, Dean, you've hit the wall. It happens."

Dean couldn't believe what he was hearing. All his life he'd been led to believe that he'd be upgradable whenever new technology came along. And now he was being told that he was obsolete, an antique, washed up at the ripe old age of thirty-seven.

"So that's it? I'm out of a job?"

"Of course not," Virgo said. "The company has invested a great deal of time and money in you, Dean. You'll be reassigned. Perhaps accounting, or how about the shipping department? I believe they have some mid-level management positions opening up down there."

"Great," Dean muttered. "I've always wanted to be a shipping clerk. What about my salary? And the apartment?"

"I'm afraid you'll be working at a slightly reduced salary," Virgo said. "And

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you'll have to give up the apartment. It's already been promised to Ms. Barton-Higgins. . . ."

Dean clinched his fists as he felt the anger returning. *Smug bastard, this is my life you're fucking with. You could at least show some regret.* Then he remembered that AIs weren't capable of feeling regret, or any other human emotion. It was one of the things that made them so effective in business.

"What about Ronald? We've been together a long time. If I'm making a move, I want him to come with me."

"I'm afraid that won't be possible," Virgo said. "Ronald has completed his intended service life. You'll be given a new, state-of-the-art assistant."

"What'll happen to him then?" Dean asked, although he already knew the answer.

"He'll be sold off as scrap equipment," Virgo replied. "Chances are he'll end up in a maintenance or manufacturing application."

Birds of a feather, Dean thought. *Maybe we can both find work in a museum.*

"Don't look so disconsolate," Virgo said. "There may be hope for you yet."

Dean blinked. "What're you talking about?"

"Our engineers are pursuing a line of research that looks quite promising."

"Research?" Dean said stupidly.

Virgo nodded. "They believe that in the near future brain transplants may be feasible. Your mind could be recorded into a database, then downloaded into the new brain. Who knows, perhaps you'll get that upgrade after all . . . ."

After Virgo said goodbye and broke the connection, Dean stepped over to the window and spent several long minutes staring out at the Manhattan skyline. At some point he realized he was trembling.

But it wasn't anger that he was feeling.

It was fear.

* * *

Dean? What are you doing, Dean?

"Leaving." He was in his office, standing over the small steel safe that housed Ronald's container. "Didn't they tell you? I don't live here anymore."

I've been instructed to assist you in your reassignment, Ronald informed him. *I've been given the updated list of openings in Shipping, Accounting, Data Processing and Customer Service. Also, Bob Givens from Human Resources would like to meet with you sometime tomorrow.*

"Tell him . . . tell him I'm going on vacation. . . ."

Dropping to one knee, Dean punched a sequence of numbers into the safe's keypad. The door clicked and swung open. Inside was a cylindrical container housing the mass of neural paste that constituted Ronald's entire phyiscal being. Dean had once watched a maintenance tech do an upgrade on Ronald. The man had worked a new layer of paste into the amorphous brown lump inside the container, like a baker kneading bread dough. It had seemed like a decidedly low-tech way of upgrading a rather advanced computer system.

Dean? Dean? What are you doing?

"Did I ever tell you about my wife?"

Your wife?

"Yeah. We were married for almost ten years. We had a pretty good thing going for awhile. I mean we had our rough times like everybody else, but we always worked through it.

"Then we decided to have kids."

I don't know why you're telling me this, Dean. I think you should be focusing on your new work assignment—

"She wanted natural children," Dean said. "I thought they should be enhanced. I *demanded* that they be enhanced. I mean, I couldn't see raising a bunch of slow, half-wit kids, you know?" He shook his head. "She left me after that. I wonder now how I could've been so wrong."

Dean reached into the safe and removed an access panel, revealing a se-

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ries of toggle switches and corresponding LEDs.

He keyed the switch marked "Format," and the following warning immediately appeared in the center of his vision: CAUTION! A FORMAT OPERATION ON THIS SYSTEM WILL RESULT IN A PERMANENT LOSS OF DATA. PROCEED YES/NO.

"Sorry, old buddy," he said. "You know too much about me. Besides, I don't think you'd enjoy running an assembly line for the next fifty years."

Dean chose the "yes" icon, and his internal workscreen immediately began to flicker and dissolve.

Dean, what ... De ... doing to ... malfunc ... func ... tion ... The voice trailed off into silence.

Dean stood up. For the first time since he could remember, there were no voices inside his head, no lines of data scrolling along the edge of his vision. He stood there a moment, listening to the silence, marvelling at it.

Then he picked up his suitcases and walked out of the room.

As he was making his way across the terrace to the helipad, a sound caught his attention, a faint splashing that stood out from the usual pops and gurgles of the pool. He stepped over to the pool's edge and saw Iago floating face-down in the cobalt blue water. The ersatz owl was thrashing its wings in a vain attempt to reach landfall. Dean put down his suitcases, grabbed the cleaning net, and scooped the bird out of the water. He felt like a sports fisherman on a saturday holovision show bagging a native trout.

Free of the net, Iago gazed up at him with its huge, vacant eyes. Dean could feel delicate, unseen mechanisms at work beneath its waterlogged feathers. "Christ, you are hopeless, aren't you?" He shook his head and smiled despite himself. "OK, I guess you're coming too."

On the helipad, the Tristar was already warming up its engines. The 'copter was Dean's, bought and paid for with his own money, and he planned on selling it just as soon as he got settled in his new home.

The door slid open and he climbed inside. He squeezed his luggage into the overhead rack, strapped Iago into one of the seats, then sat down himself.

"Destination?" the autopilot asked.

"Pennsylvania," Dean said. "Lancaster County."

"Could you be more specific, sir? My topographical maps do not reference counties outside the state of New York. Perhaps if you could provide me with the GPS coordinates, I could—"

"Just fly," Dean said. "We'll find it."

The 'copter lifted off the pad and moved into the westbound traffic lanes. Dean sat back and closed his eyes. He half expected to find some cryptic message lurking behind his eyelids, but there was only the reddish darkness of his skin.

Somewhere over the Central Park Biodome, he turned to the drink dispenser, but rather than choosing a mineral water, he poured himself a beer instead. He sat there for a long time, sipping the strange amber liquid and contemplating the uncertain future that awaited him.

He wondered if this was what it felt like to be free. ■

Sometimes there are exceedingly brief periods which determine a long future.

—Bernard DeVoto

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THE MARINOV MOTOR & ME, PART 2

In part 1, I described an interesting little electromagnetic toy I (and Tom Ligon and Dr. Tom Phipps) have been playing around with called the "Marinov Motor." This motor is interesting because it seems to violate, rather flagrantly, one of the cornerstones of classical electromagnetic theory—that stuff every engineer learns in his freshman or sophomore year of college—specifically, the Lorentz Force law. Part 1 has a diagram showing the basics of this motor and the reader is referred there if he needs to see what the "essential Marinov Motor" looks like. Here I have a different, more schematic representation of the motor, a version I invented which I call the "Warlock's Wheel."

Let's look over the diagram. In the middle you see the cross section of two rare earth bar magnets, with *N* up on the left and *S* up on the right, the magnets held together, with or without an intervening separator, by their own mutual attraction (which is considerable when using magnets in the kilogauss range). The magnets are surrounded by a copper ring which is free to rotate in the plane of the page. Traditional current is brought in from the left, transmitted into the ring via a mercury brush, splits up and goes both ways around the magnets, then is drawn off through a similar brush on the right side.

The magnetic field lines associated with this pair of magnets needs to be considered. At the 9 o'clock position the field points down into the page as shown by the "X's." At the 3 o'clock position, the field points up out of the page as shown by the dots. At 12 and 6 o'clock, the field is nearly zero since these are the positions where the field reverses direction. Also, although with my motor I made no attempt to confine the field coming from the magnets by using soft iron keepers across the top and bottom, by simple inspection we know that the field is most intense right between the poles, but less intense at the position of the ring (bear in mind that although I show the magnets in cross section, they actually project a couple of centimeters above and below the ring plane).

For the case shown in the figure, if the ring is held fixed and the magnets allowed to turn (say you put them on a shaft or suspend them from a monofilament line) from their initial position, the magnets will start to rotate counterclockwise. If the current is left on after the magnets start to turn, when they rotate past 90 degrees they'll enter a region of reversed polarity and begin to slow down. If you pulse the current so that it is off by the time the magnets hit that 90 degree position, momentum will carry the magnets around back to their starting position, and another pulse of current will speed them along even faster.

If the magnets are fixed and the ring is free to rotate (with mercury contacts on the outside of the ring), upon application of continuous current the ring will rotate clockwise *continuously*.

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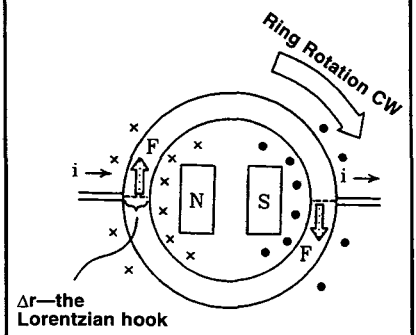
Once Ligon, Phipps, and I published our preliminary findings, we naturally received feedback from folks who were certain they could explain the motor in conventional terms. These criticisms (at least those that weren't entirely out to lunch) fell into three categories: the lead wires; unbalanced mechanical forces; and the homopolar effect.

Before proceeding, I need to point out an experimental fact. If you suspend an ordinary bar magnet with one pole up, and run a DC current through a wire near it, you'll see the magnet either be attracted to or repelled from the wire, and changing the current direction will reverse things. In ordinary theory, the field from the magnet acts upon the current in the wire causing the wire to feel a force in obedience with the right hand rule spelled out in the previous column. The current-carrying wire sets up a field in the vicinity of the magnet and the magnet responds to that much as it would to another nearby permanent magnet.

The "lead wire criticism" suggested that the turning magnets didn't turn because of the ring at all, but because of the leads which our diagrams showed pointing straight out from the ring. It was asserted that the field from the leads "reached forward" so to speak and set up a weak transverse field which the magnets wanted to rotate into alignment with. It only took Ligon and me a few minutes to try the lead wires in different orientations, specifically coming in to the ring vertically, and we found that the leads had little or nothing to do with the magnet pair's motion. (Note to those with a copy of part 1 in front of them: translate between "magnet pair" and "torus" as need be. Since I couldn't show both diagrams in both parts, I've adjusted the terminology to fit the diagram in each.)

The next criticism of merit says that the "canceling of forces" that we thought was happening was not happening perfectly. In short, if the magnet

"The Warlock's Wheel"



(illustration courtesy Tom Ligon, assorted tehcnical expertise)

pair was a bit off-center, or the fields were a bit less symmetrical than we thought, then the forces on the ring would not cancel perfectly and there would result a slight torque, enough to make the ring rotate. I can't say I've entirely ruled out this possible contribution to the motion. Yet most of my work with ring rotators has taken place with a ring suspended by a single thread, so if unbalanced forces of this kind were causing rotation, one would expect some "wobbling around" of the ring, and I've seen only a smooth spin up from a standing start.

The third criticism/explanation is that the Marinov Motor is really some kind of homopolar motor or Faraday disk. Faraday found that if he rotated a conducting disk through and at a right angle to a magnetic field, a current could be drawn off the disk if brushes were connected between the rim and the axle. This is a homopolar generator. It is supposed to be the case that doing this backwards (running current into a homopolar generator) will set the disk turning. (If you've never heard of this device, don't worry—few have. They are produced commercially, though.) In the case of the Marinov Motor, many suggested that the leakage field was interacting (via right hand rule) with the radial compo-

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nents of the incoming and outgoing current. In short, that little part of the current crossing the width of the ring ("delta r") was providing the "Lorentzian Hook" for the magnetic field to use to cause ring rotation (see diagram). The only problem with this idea is that the force on the ring should depend on the width of the ring. So a thin shell substituted for the ring (with the same average radius and an identical moment of inertia) should accelerate much, much slower than a ring. (In math terms, recalling the Lorentz Force law F = iL x B, as L shrinks, F should also shrink since B and i remain the same.)

It doesn't.

This was great! Here we had a nice big effect being produced in an easy-to-build apparatus, and the physics textbooks were strangely unhelpful when it came to explaining how the darn thing worked. I wrote up a rather thorough paper on the motor for *Infinite Energy* magazine entitled "How To Think About the Marinov Motor" which laid out how the magnet/ring assembly "should work" if all was according to Hoyle in the world of E&M theory, but detailing how it really *did* work in our world.

They say that the secret of successful experimentation is knowing when to quit. I did not know when to quit, and the Marinov Motor bit me with a vengeance.

In Part 1 I said the motor did something so spooky that it left me speechless. Here is what happened.

The editor of *Infinite Energy*, Gene Mallove, asked me to speak on the Marinov Motor at the Cold Fusion and New Energy Symposium 1998. I was also encouraged to write my results up in a form suitable for an "Establishment" publication. But to do this, I wanted to redo my work in a more formal manner—most of my experimentation had been rather *ad hoc*, not much more than just messing around to see if there was anything to this Marinov Motor business or not.

With this in mind, I built myself a better test rig, and used low-friction mercury brushes in place of foil ones for the first time.

Oh, that first run was beautiful, so smooth, so crisp—weird physics at its best. The mercury brushes were positioned on the outside of the ring, just as shown. The ring rotated clockwise just as it should.

But then I put the brushes to the inside of the ring. Everything else remained the same. The ring rotated the other way.

Uh oh.

Recall what I said earlier about rotating the magnets with the ring fixed. It didn't matter how one brought in the leads, or whether or not the leads were connected to the inside or the outside of the ring for that matter. Always the magnets would turn the same way.

I rebuilt my Marinov Motor. I made it so that both the magnets and the ring would be free to turn at the same time.

We had assumed from the start, right from when Ligon hung his first torus and held a ring around it, that the ring should feel a torque in the opposite sense from the torus (or magnet pair) like other electric motors—all of which have shafts that rotate opposite the direction that the housings would want to go. Nothing we did suggested otherwise and we were careful to eliminate anything other than the ring being what the magnets were pushing against to turn.

Yet from a standing start, upon application of current, with my new motor I was able to set the ring and magnets in motion in the same direction. The magnets (against the drag of cold pancake syrup—I had to damp their motion) started to turn counterclockwise. The ring began to rotate counterclockwise, accelerating until the magnets had finished a quarter turn.

And now, the questions: ***Just what in the hell are these two things pushing against if not each other? Between what is Newton's third law acting?***

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I'll leave it there. I'm out of space anyway. You folks think about it. Hell, build one of your own. You can consult the copies of *Infinite Energy* cited at the end for more detailed information. I made a video of my results, calling my version of the motor the "Warlock's Wheel" as befits its spooky nature. By the time you read this, a copy of the video might be available for purchase.

As for me, I first violated Newton's third (if that's in fact what I really did) back last spring. Flabbergasted, speechless, and not knowing what to make of it, I went out and cut the grass.

I've cut a lot of grass since then. □

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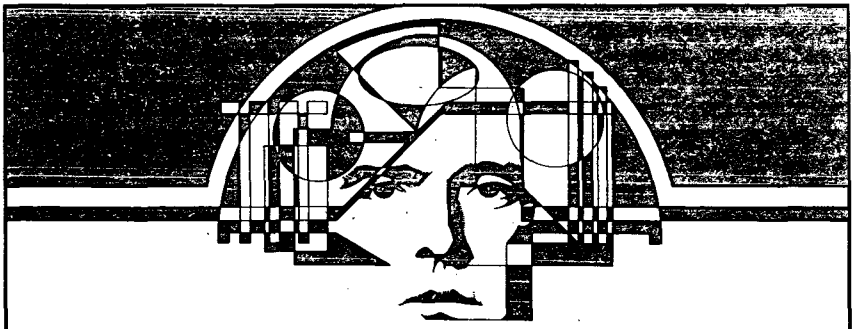

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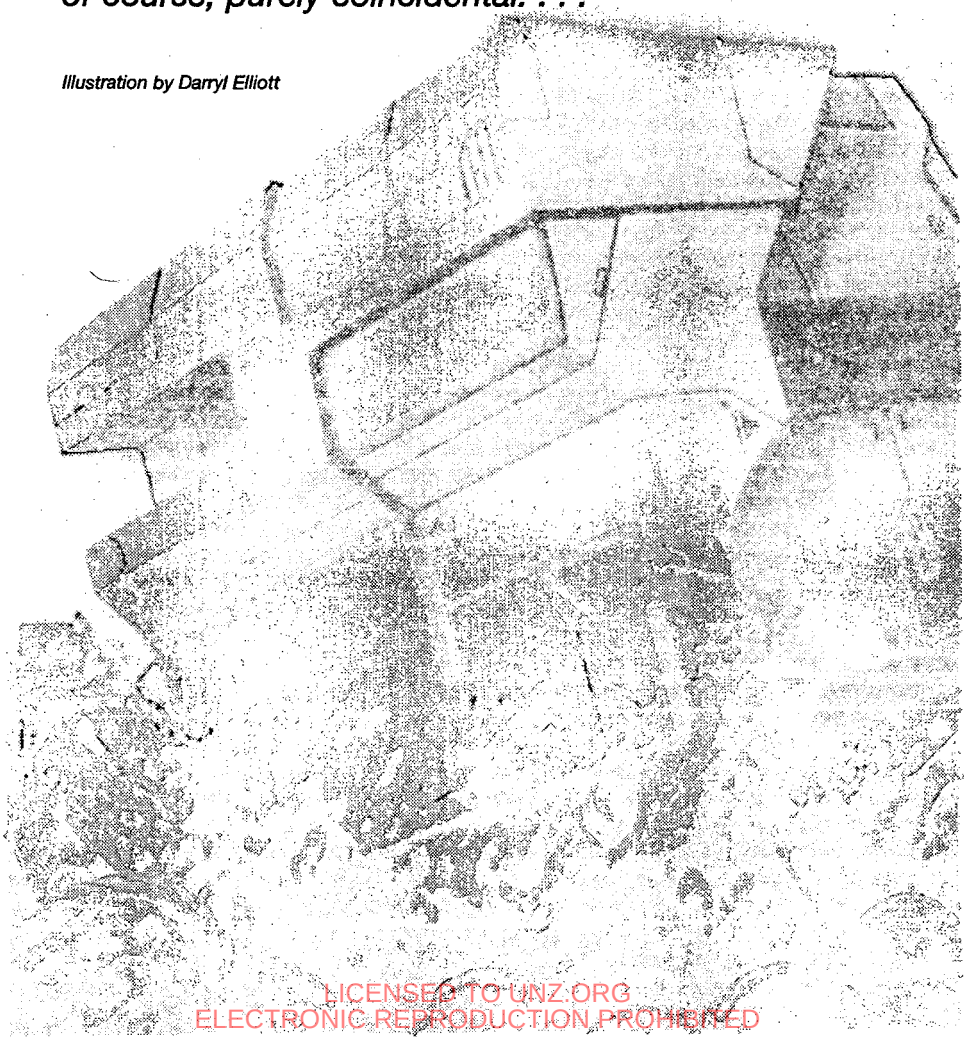
Uncle River

THE DASHING ABOUT FLYING BOX PEOPLE

Any resemblance to anyone we know is, of course, purely coincidental. . . .

Illustration by Darryl Elliott



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In youth, Eblio traveled to such distance that even the birds spoke a different language. Over all that distance, Eblio learned to speak with People. So, of course, when the Flying Box People arrived, Eblio went out with the greeting party, at least as intrigued as frightened.

One heard of Flying Box People. They were ignorant, of course, of People's ways, and did some awful things, not knowing any better. But they seemed to intend friendship. "No knowing what harm we may do them in ignorance," Levery said to Eblio. Eblio agreed. One could make awful mistakes through ignorance, even among People only a few days' walk away.

For a species who start life as plants, and whose reproductive function amounts to wind pollination, the Cratons appear to have social organization more like human than some whose biology is far more similar. But then, other than reproduction, they are *pretty similar to human. They cultivate food. They make copper cook pots. They live in communities, mostly of a few hundred individuals, that almost certainly have to do with both survival benefit of division of labor and interpersonal relationships. Their sentient adult phase sees, hears, feels, probably smells and tastes or something of the sort. They raise their young ... which they pick like berries from bushes!*

Gemma Long, Xenologist
Xenological Survey Service
Field Notes, Craton V

It was a spring morning. Tiffletae fluff wafted through the air like a reminder of snow. And to think that tiffletae trees gave birth to sleepy, sluggish griffletae, that snuffled about all winter eating their own trees' dead leaves, and mostly just slept in their shells in summer. Well, Flying Box People were not the only oddities of Creation.

Eblio was out in the garden irrigating when the Flying Box People arrived. Everyone knew what they were, of course. They had been seen several other places, mostly off to the east where the lowlands were so humid and People grew sleepy as griffletae on summer afternoons. No one had really managed to talk with the Flying Box People yet. But there had been enough rudimentary communication that People understood the Flying Box People to have come from another world ... someplace so far away that its sun appeared as a star. What one might learn, Eblio thought, if only we could talk!

"Do you think they really have a language?" Levery asked.

Levery and Eblio walked together, with about twenty other People, to greet the Flying Box People. Several children, who were themselves just learning to talk, scampered behind—still intoxicated at the newness of their own mobility.

"They must," said Eblio. "I don't believe they could make the things their journey required without."

"Well, birds speak enough to tell each other where food is, or danger," said Levery.

"Or where they're from," Eblio replied. "But they don't fly in a great, shiny, metal box." Eblio reflected, as Eblio and Levery and the rest of the greeting party approached the Flying Box People, who saw them coming and stood outside their metal flying box in their own waiting greeting party. "No, Levery. They're not like birds. The Flying Box People have some sort of real language, and I'm going to try to learn it."

I believe that tonality is as important to Craton language as what we hear as words. Perhaps, with sentience, their language developed from the sounds ... songs almost, like bird songs ... that stimulate their metamorphosis chemistry.

Gemma Long, Xenologist
Field Notes, Craton V

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* * *

The Flying Box People stayed many days, but as a curiosity they rather waned for most People. The Flying Box People walked about, looked at things, noted what they observed in some sort of devices that People could no more comprehend than one could expect Flying Box People to comprehend story cloths. Actually, the Flying Box People didn't just walk about. The Flying Box People did a great deal of agitated rushing back and forth, for no apparent reason. Sometimes they made destructive messes . . . like any ignorant animal. But they showed sufficient consideration to confine most of their most-agitated dashing about, with its destructive aspect, to a discrete encampment around their metal flying box and away from People's gardens and homes.

The Flying Box People also had several little flying boxes, that they brought out of the big one, and which they used to dash about at greater distance than one could walk. They even offered People rides. It *was* exciting. But hardly practical. When one stopped, having traversed, in half a morning, a distance it would take many days to walk, without having learned anyone's speech along the way, anyone who one met might as well live on some Flying Box World for all one could understand of their speech or even their story cloths.

To go inside the Flying Box People's big flying box, as they escorted several People who wished to see, was scary, and thus even more exciting. But lacking common language, most of what one could see in there was unintelligible.

People and Flying Box People exchanged some gifts. The Flying Box People could eat most of the food that People ate. Tender fibbith greens were in season. The Flying Box People seemed to appreciate having something fresh to add to their diet. As other crops came in, People offered some of them too. The Flying Box People seemed to like most of them. There were only about twenty-five Flying Box People. It was hard to tell them apart enough to be sure how many. But they had considerable supplies. Offering them some garden produce was not a hardship.

With People visiting from a distance, one might exchange story cloths. But there was no point to give the Flying Box People story cloths until . . . or unless one could share enough real speech for the story cloths to mean anything. But the Flying Box People seemed able to appreciate beauty. So People gave them several pattern cloths.

The Flying Box People gave People a picture which they seemed to consider significant, of several circles of various sizes. They managed to communicate that this had something to do with the world and the sun . . . or maybe *their* world and sun. Why this mattered to them, who could say? But, of course, People appreciated that their visitors gave them something the foreigners considered significant. The Flying Box People also gave People several useful tools: three sizes of vegetable knife, of a hard, silver-grey metal that held an excellent edge, a house-peg hammer of some similar metal, a light that would shine all night if left in the sunshine during the day.

Well, this was all reassuring, as well as interesting. But there were gardens to tend, and homes and children and friendships . . . and a few quarrels. When nothing different happened, most People went back to everyday pursuits and each other, and only greeted the Flying Box People as now-familiar, if very foreign, guests, who spent most of their visible time dashing about in great and incomprehensible urgency, expending more energy than a tree-hip-flip . . . to less practical effect.

Eblio, however, determined to learn the Flying Box People's speech. Watching them more closely than most, Eblio gradually came to distinguish one of the Flying Box People from another. A few

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of them anyhow. Strange creatures they were really, a little smaller than People, but not much. The Flying Box People wore clothing, in various colors, bright and subdued, which might or might not signify anything, but did seem to indicate some sort of aesthetic. What *did* the Flying Box People regard as beauty? What *did* matter to them? They had rather wide faces, in various shades of pink and brown, and thick fur on various parts of their heads, some more, some less, of various lengths and colors. Did the variations signify anything?

No knowing. But the Flying Box People certainly did dash about a *lot*.

Of course, one could not expect Flying Box People to understand that one should apologize when tearing up a People-bush. And People tore up People-bushes all the time, along with numerous other sorts that would overrun everyone's gardens and homes in a season if one did not. But there was something odd about the Flying Box People's urgency, about their attitude toward *each other* in their urgency. Back and forth they rushed, tearing things up, moving things from one place to some seemingly-arbitrary other place, making so much noise that how could anyone concentrate? Back and forth. Back and forth!

"I wonder," said Eblio to Levery one dawn over clear-soup. "I do believe they intend friendship, but something about them makes me very uncomfortable."

"Well, they *are* aliens," said Levery.

And that was true enough. The more reason to learn to speak with them.

A breakthrough! Though I am embarrassed to admit that it is the Craton who made the breakthrough. I'm not even sure what happened. I think the Craton figured out what constitutes words to us. I still can't say the same about theirs. Maybe soon the Craton can tell me. Whatever it is, we now are communicating in words. Mostly nouns; a few verbs. I think the lovely trill the Craton made on comprehending "walk" and "run" was something like a laugh of pleasure.

Gemma Long, Xenologist
Field Notes, Craton V

"They do have a language," Eblio said, excitement warbling like long-awaited summer rain. "It's very strange . . . Like the eastern Lowlanders who sing up a day hot and wet enough to sprout purple iskiss, and sing down altogether different a day so hot and wet that the iskiss sprout yellow."

"The Flying Box People's speech sounds very crude to me," said Levery. "No more melody than a grey-down frufowl."

There was nothing nicer than a pillow of frufowl down, but it was true that their speech consisted only of a dozen sorts of raucous squawk. How frufowl young could quicken at all to such a toneless, meager range of sound was a mystery.

"Indeed," Eblio replied, "it is all but toneless . . . . Well, not all the time. Actually, they *do* sing. *Very* strange, but . . . I won't say lovely. Exotic. But their speech. The meaning is mostly in the precise vocables. Why, it would take them half a day to describe the health of a patch of lisk beans, but they could tell you how many there were before you could count the first plant."

"How can they do that?"

"Well, now," said Eblio, "I'm confusing myself. They'd have to count them too, of course. Well, that's not it either. But . . . Let me show you."

Eblio made a sort of skrawking sound, then strode across the yard. Eblio made the same sound, then ambled back, smelling the fragrant, summer morning air. Eblio made that same sound several more times, each time crossing the yard a different way. Then Eblio made a different sound, and sprinted across the yard, both feet completely off the ground at once at each step. This second sound, too, designated a whole array of modes to cross the yard.

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"What's precise about that?" asked Levery.

"It's in the . . . distinction," said Eblio. "In the . . . edge. Like the vegetable knives."

"I suppose." Levery was not sure, but also was less interested than Eblio. "Do you think that means that on their world a Person could walk for twenty-three days, and everyone would speak the same, and then on the twenty-fourth day you would come to People whose speech might as well be from a different world?"

"Maybe!" said Eblio. "That would make their little flying boxes more practical. If I can learn enough of their speech, I'll ask."

Eblio did learn more of the Flying Box People's speech. Eventually, Eblio could converse with them enough even to begin to comprehend their interactions with each other. Eblio became more uncomfortable at this, not less. The Flying Box People had an agitation to them which pervaded their interactions. Yet this essential quality of the Flying Box People seemed completely absent from what the things they *said* led them to *do*. Eblio began to wonder if the Flying Box People *were* altogether sentient.

People, after all, lived a whole other life as People-bushes, which sprouted and grew, shed clouds of pollen, flowered and made People-berries, grew leaves and shed them, and died, all without any sentience really. Only the very few People-berries that sang back to People-Singing, and which People found, to pick and bring home, and to feed People-soup, metamorphosed into children, who one got to know and to love and nurture and raise up to become sentient People. What if, just as their language held its meaning in so-alien a part of its own structure, the Flying Box People also . . . carried a non-sentient aspect of themselves with them, which had a life of its own, of which they, perhaps, were not even aware?

The more Eblio observed the Flying Box People's behavior, what they did, how their attitude felt, the discontinuities between what they did and what they said, the more Eblio came to suspect that the Flying Box People themselves did not know their own full natures. How to ask about this? Did one dare?

Tonality is *an essential part of the Cratons' speech, but that's just the start of it. There is an enormous subjective element, which may well be the limiting factor in the size of their communities. Nouns, including names, and verbs sort of function as consistent sounds, at least within a community, though I gather that even they vary from community to community, increasingly with distance. And all the qualifiers that express what anything means* to *anyone vary from individual to individual, and with mood. The Cratons have a highly-evolved, very full language, but can only really share it fluently with others who they know personally!*

Gemma Long, Xenologist
Field Notes, Craton V

It was no longer spring. In fact, it was getting on toward no longer summer, with nights cool enough that one even heard a griffletae snuffle about in the tiffletae leaf duff, when a much-preoccupied Eblio conversed, one luxuriant afternoon full of greenery and flowers that filled the days after late-summer rains and before frosts, with the Flying Box Person called Gemma, at the edge of the Flying Box People's encampment.

To People's eyes, it was a rather ugly encampment. Well, one could not expect Flying Box People to feel about bushes and flowers that they didn't know as People did. The Flying Box People *did* have both feelings and an aesthetic. Eblio had grown to know them, and to know the Gemma Flying Box Person personally, well enough to feel sure of this. Yet Eblio could not help feeling

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that the Flying Box People's encampment laid bare the ground in a gratuitously destructive manner, whose maintenance had *some* other element beyond foreignness and ignorance.

Eblio did not wish to insult the Gemma Flying Box Person, but felt much need, and almost ready to ask . . . something, when one of the other Flying Box People walked up and greeted them:

"Attention, Frivolity," the other Flying Box Person said to Eblio. Then the other Flying Box Person turned to the Gemma Flying Box Person and said, "Attention, Tasty-Emotion-Food. Do you perpetually dash about in mandatory screaming insanity, wantonly destroying things and hurting People?"

The Gemma Flying Box Person replied: "Seal up your intestines in a vacuum box, Bart."

Eblio recognized the sound, "Bart," as the other Flying Box Person's name. Eblio recognized the Gemma Flying Box Person's response as somehow entailing personal animosity to the Bart Flying Box Person. But, the personal reaction was a reaction *to something* in Flying Box People interaction generally, which was *not* personal.

Eblio ran away. Eblio did not know how to express at all, let alone how to ask aliens about what called up such fear. But it was too much! Emotion turned to action as sure as the wind blew pollen . . . whether of People-bushes or of izvi-bushes that made a tangy fruit and no mobile creature at all let alone sentient.

Eblio was only too aware that sentience did not stop fear from impelling Eblio to flight.

"I think the Flying Box People may *intend* friendship to us," Eblio later said to Levery. "But I am terrified of what they do without intent."

Officer Second Class Bart Holder walked up to Xenologist Gemma Long while she was in session with Craton E-[rising mode]-bl-[gutteral/indrawn]-io-[high/low; fourth]. Officer Holder greeted the Craton: "Hey Sport." Officer Holder greeted Xenologist Long: "Hey, Beautiful. Staying busy?"

Xenologist Long replied: "Can it, Bart."

The Craton ran away.

Board of Inquiry
Craton V Xenological Survey

The Flying Box People didn't do anything *really* awful. Rather, Flying Box Person Gemma came out, day after day, about halfway between the Flying Box People's encampment and the nearest gardens. Eblio finally decided that Flying Box Person Gemma's odd gestures and calls and things laid out on the ground were intended as a sort of ceremonial placating behavior.

The first frosts came, to sweeten red lisp fruit . . . and to ripen People-berries, most of which would just be eaten by birds or small animals, or fall to the ground. Quite a few would sprout new People-bushes. But it also was time for the People-Singing. A community as large as Eblio's, of almost three hundred People, could expect to bring home at least three or four quickened People-berries most years, possibly as many as eight or ten awakening People-berries, that would go into metamorphosis over the winter.

Not that the Flying Box People appeared to affect this all-important annual event one way or another. But the season . . . and, well, the invigorating fall weather that went with it, filled Eblio with a sense of responsibility. So Eblio went out to greet Flying Box Person Gemma again. They talked further. Perhaps neither came away fully at ease. But they managed to reassure one another sufficiently to resume their conversations.

The Flying Box People observed the year's People-Singing, from a considerate distance. Four People-berries answered this year. By the time the Flying Box Peo-

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ple departed, with deepening snow of Solstice-tide, the People and Flying Box People parted on friendly terms.

Well, personally, Eblio liked the Gemma Flying Box Person . . . to the degree that one could know how one felt at all of a being so foreign. And Eblio felt that the Gemma Flying Box Person reciprocated personal friendship. Of the Flying Box People generally . . . Eblio was just not sure.

Eblio had explained the exchange which had caused Eblio's flight. The Gemma Flying Box Person had tried to explain that personal feelings had leant that exchange a meaning not accurate to its actual words. Well, perhaps. But Eblio remained unsure if the Flying Box People were fully aware of their own natures.

"So the Craton plant-person didn't like Officer Bart's disgusting come-on any better than you did, eh Gemma?"

"I doubt the Cratons understand yet that there is any such distinction as male and female in our species, Antoinette."

"But you say they're fully sentient?"

"Yes. Type I. High intelligence."

"If it wasn't Officer Bart's crude sexual harrassment, why did that Craton run away?"

"Tone plays a large part in their language, Antoinette. Feeling tends to inject tone into their words . . . somewhat as singing a phrase conveys feeling, and thus meaning with it. What scared the Craton was the phrase, 'Staying busy?' In context, what that phrase translated to was more or less: 'Do you perpetually run about in mandatory screaming insanity, wantonly destroying things and hurting people?'"

"Ah hah! No scheduling ulcers on Craton V. Eh, Gemma?"

"Well . . ."

"I'm afraid we're out of time. Thank you Gemma Long, Xenologist, for your fascinating adventure with the singing plant people on wild, beautiful, laid-back Craton V. Be sure to be with us tomorrow when our guests will debate the raging custody fights in wake of the tragic Memphis quake. Who would you favor to raise an orphaned eleven-year-old? The deceased mother's clone, who is only nineteen herself, or the mother's sixty-eight-year-old sister? Keep those polls coming. And thanks to all of you for making 'Antoinette Asks' the most-popular show in its time slot for yet another month."

Interview, Gemma Long,
Xenologist
Xenological Survey Service
Antoinette Asks

It was four years before any more Flying Box People arrived. When more Flying Box People did show up, Eblio was among those to greet them.

It was a few days, though, before Eblio had time to do much more than greet them. It was late spring and very dry. New little seedlings with not much root yet were come up all over the garden. It took a lot of irrigating to keep the soil moist enough for the seedlings to develop deeper roots. All that irrigating sprouted lots of weeds too. Eblio, and everyone, had a lot to do.

A greeting party did walk out to the new-arrived Flying Box People's metal flying box though. Courtesy and curiosity alike required that much. Eblio was among the greeting party. Eblio didn't know if it said anything one way or another about the Flying Box People that the new arrivals included none of the same individuals who had come last time. There seemed to be about forty of them this time.

"Is among you Craton E-squawk-bloop?" one of the new Flying Box People asked.

No one knew what to make of that. But as Eblio was the only Person who actually knew how to talk any Flying Box People's language . . . and the new Flying Box Person did seem to speak something like the same language . . .

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Eblio replied: "Greetings, Flying Box People visitors."

The Flying Box Person who had spoken was about the same height and color as the Gemma Flying Box Person, a bit thicker of build, with curly, light brown fur on top of the head that fell to the Flying Box Person's shoulders. "Oh, you must be Craton E-squawk-bloop," the Flying Box Person said.

Eblio realized that the Flying Box Person was trying to say, "Eblio." Well, even the Gemma Flying Box Person had a hard time to pronounce Eblio's name correctly. What "Craton" meant, Eblio had no idea. Some sort of title used to greet strangers, perhaps?

"I am Eblio," Eblio replied to the new Flying Box Person. "Have you come to learn more of People's ways and to inform us more of yours?"

The new Flying Box Person replied, with what seemed to Eblio considerable enthusiasm: "Oh, magic-dwelling, lie-on-your-back, we come to eat your music trees!"

Eblio thought that the Gemma Flying Box Person had said that all Flying Box People *did* speak the same language over a wide area. Perhaps this Flying Box Person came from someplace very far from the Gemma Flying Box Person's home. Or perhaps what Eblio understood the Gemma Flying Box Person to have said was not accurate ... in some way that Eblio and the Gemma Flying Box Person had not quite managed to articulate to each other.

Further conversation with the new Flying Box Person only confirmed Eblio's doubt that People and Flying Box People were communicating. Eblio *hoped* that at least a few basic practical points came across clearly. Well, terms for things, such as, "encampment," or, "this place," had been easiest with the other Flying Box People. Eblio had no idea what to make of the new Flying Box People's talk of "magic-music," and, "tree-doze," and, "self-knowing-food."

Most of the greeting party, unable to understand even as much as Eblio could of what the Flying Box People said, had gone back to their gardens and homes by the time Eblio said, "I must irrigate the free-seed sprouts. Let us talk again another day." The new Flying Box People *did* indicate, Eblio was fairly sure, that they intended to stay ... some extended time.

Free-seed sprouts. What an Eden! And their voices, like birds! Well, Cratons don't look much like birds. Of course they don't look much like humans either, with their long faces and sturdy, grey-brown arms and legs. But such a ... harmonious, natural life!

Marion Varna
Love Star Tours
Craton V Journal

The new Flying Box People were as agitated as the others, but they did things differently. Where the first party had been methodical, the new ones cast their belongings about chaotically. Where the first group had scurried about and talked to each other in almost ceremonial patterns, the new Flying Box People dashed hither and yon ... sometimes right into People's gardens or even their homes, in no comprehensible pattern. The new Flying Box People also frequently paired off and grappled with each other, which the others had not done, or at least not done in public view.

"Well," said Levery, "we know now that there *are* differences from one community of Flying Box People to another."

"Yes," Eblio replied, "but I am not sure they know it. I'm not even sure they know their speech is different."

"How could that be?" Levery asked.

"I don't know," Eblio replied. "Maybe a non-sentient aspect of them affects their speech in some way of which they are unaware, but is part of how they form communities."

"Well, you know more of them than I do," Levery replied.

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This was true. But what Eblio knew did not make a lot of sense. In fact, Eblio felt that knowing two communities of Flying Box People was more confusing, rather than more informative, than knowing just one.

Eblio never did get to know any of the new Flying Box People as an individual as Eblio had been able to do with the Gemma Flying Box Person. None of the new ones seemed to want to bother. Well, no other People had wanted to bother either, with the first party, any more than now. It *did* take a lot of time and effort with People whose language held so alien a structure. But Eblio would have given that time and effort. Except, Eblio could not figure out what any of this new party of Flying Box People did want.

Nor could anyone else. The first party had wanted to learn about People and the world. This made sense enough, even if a lot of their specific behavior did not. This new batch, though, came and went erratically, and did not make any of it clear. They actually tore up fewer People-bushes than the first party had. Some of them *talked* to People-bushes. Some of them talked to all sorts of plants and mobiles. If this made any sense by Flying Box People standards, who could say? They talked to People sometimes too, despite the fact that most People could not understand what the Flying Box People said . . . . And the new Flying Box People made little effort, so far as anyone could tell, to make themselves comprehensible . . . or to understand what People said to them.

Which mostly mattered only when the Flying Box People did damage. Which they did considerably more than the first party. . . . Perhaps because the new ones didn't consider. That the first batch of Flying Box People had been . . . well, foreign, alien, was only to be expected. But they *had* paid attention, had made obvious effort to be considerate, had done rather little damage, and almost none once Eblio and the Gemma Flying Box Person could communicate enough for Eblio to explain why, for instance, one must not put wastes where they would contaminate the roots of trailing sleevo-vines, whose extent one might not realize without someone who knew explaining.

The new Flying Box People did bizarre things. They asked People for copper cook pots . . . which the Flying Box People did not use for cooking, and which Eblio was quite sure they did not need as they had plenty of cook pots of their own . . . which they did not offer to People. Eblio wondered if the Flying Box People had any idea how much work it took to make a copper cook pot . . . or how they made their own. Eblio would have asked the Gemma Flying Box Person, but didn't know who to ask of the new party.

The new Flying Box People also asked People for both story cloths and pattern cloths . . . and various articles of clothing and household furnishings. Eblio became increasingly certain that these requests were neither for practical use nor to learn People's ways, but were arbitrary whims.

Sometimes the Flying Box People offered some object in exchange for things they asked for. These objects might be interesting, or even useful. But again, Eblio became increasingly convinced that the choice of what the Flying Box People offered was mostly arbitrary. And considerably more often than anything else, the Flying Box People offered only some incomprehensible little signs on thin, flat objects. Eblio understood these signs to have to do with quantity, but quantity of what Eblio could not tell. People became less and less inclined to give the Flying Box People what they requested, which one could hardly blame People for as the Flying Box People's requests became a significant imposition.

The Flying Box People also trampled gardens. Well, they mostly trampled only less-obvious portions of gardens. But

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they showed little inclination to learn what was there, or to keep away from what they did not understand. Really, these new Flying Box People were exceedingly rude. Occasionally, they would even do something appalling, such as to open the wall of a Person's home. On two occasions, this let direct sunlight spoil a batch of People-soup. Well, no children starved, but wantonly to cause children to go hungry! There was something very wrong about this new party of Flying Box People.

Many People grew alarmed at the situation. Quite a few wanted to learn the Flying Box People's language, to be able to comprehend, and one hoped to communicate better. But none of the new Flying Box People seemed interested to take the trouble to help anyone learn. Eblio taught others as possible. But Eblio was none too sure of the new Flying Box People's speech, to be able to teach. A lot less of it than of the first party's communicated anything meaningful even to Eblio.

Oh dear! I hope we haven't stirred up some primitive superstition. The Cratons are refusing to sell us any more of those charming wall-hangings. They won't even part with sooty old kitchen ware. Well, what can you expect from a species that leaves bowls of scummy water around and then has a conniption if you let in some fresh air?

Marion Varna
Craton V Journal

With fall and frost, People-berries ripened . . . along with lots else, which needed harvesting. There was a lot to do. Then a day came when it was time for People-Singing. As everyone feared, the Flying Box People knew enough to recognize People-Singing. It seemed that *all* the new Flying Box People wanted to come along. No one was comfortable with this. How to explain?

"Please," Eblio said to what Flying Box People's attention Eblio could catch, "do not disturb us in our People-Singing."

Whatever the Flying Box People understood by Eblio's request, it did not result in their leaving People alone to People-Sing. The Flying Box People not only followed People. But the Flying Box People followed too close, and talked among themselves the while, making it difficult to concentrate . . . and to hear! Some of the Flying Box People even made noises that sounded like a grotesque attempt to join the People-Singing.

Frosts became harder. Most People-berries had dropped. The People had found only one awakening People-berry. Well, this could happen. Eblio remembered a year when there were none. But everyone felt that there could well have been more and the Flying Box People had interfered with finding them. When People *had* found that one awakening People-berry, the Flying Box People had intruded and clustered about until People had to chase them away brandishing sticks. The People-berry had not been harmed. But, as the season neared its end and the Flying Box People continued to trail after People-Singers and interfere, the situation finally grew intolerable.

So, after some discussion, the next day, when People-Singers set out, other People took up spades and vegetable knives (including some given to them by the first Flying Box People) and sticks, and stood between the People-Singers and the Flying Box People, and waved these weapon-objects in a menacing manner.

"You, go away!" the People shouted, as Eblio had taught them, in Flying Box People speech.

The Flying Box People did go back to their encampment. Everyone was relieved. But it was necessary to chase the Flying Box People away three more times before they stopped trying to follow People-Singers. By then, the season was all but over. No more awakening People-berries were found.

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The Cratons have turned downright nasty. You'd think they would be pleased that we appreciate their exotic ritual. What do they think we're going to do? Eat their berries? It's not as if there was anything private about singing to bushes all over the landscape with a thousand berries on every one. Well, primitives can be like that about their religion, I suppose. But it is such *a disappointment.*

Marion Varna
Craton V Journal

Again, People discussed the situation. Everyone agreed. Enough was enough.

Eblio and a party of People walked out to the Flying Box People's encampment. Many of the People carried spades and knives and sticks. The Flying Box People saw the People coming. By the time People got there, many of the Flying Box People, too, held objects that no doubt were intended as weapons, though no one knew in just what manner one could use them for such a purpose. Everyone was very thankful not to find out.

"You go away!" Eblio called out, as loudly and as clearly as possible, in Flying Box People speech. "You do not know how to behave among People. We cannot have you here."

A Flying Box Person replied something that Eblio did not fully comprehend, about "violence", and, "go in a line," and, "not-true belief."

Perhaps what the Flying Box Person said mattered. Perhaps not.

To everyone's relief, the Flying Box People did pack up their encampment and go away.

"Laid-back? Harmonious? Did that xenologist ever lead us all down the primrose path! Antoinette, those Cratons grub in the dirt just like some grimy turnip farmer. Don't even know the value of their own crafts, much less care. Bunch of superstitious mud farmers. And they're violent too. Came at us with the very knives the Xenological Survey people gave them."

"Oh my! Thank you, Marion Varna, for sharing your frightful experience on primitive, spooky Craton V. As a special bonus for being our guest today, the Antoinette Asks Legal Department will provide you a full two hours of complimentary consultation in your valiant effort for just restitution. And remember, all you wonderful viewers out there. Keep those polls coming. Who do you think should be liable for this life-endangering misrepresentation? Love Star Tours or the Xenological Survey?"

Interview, Marian Varna
Distressed Love Star Tours Customer
Antoinette Asks

"I'd like to have been able to ask the Gemma Flying Box Person what that second batch of Flying Box People was all about," Eblio said to Levery. "I did like the Gemma Flying Box Person. But perhaps it is just as well if they don't come back. For a species capable of building a metal flying box, they really do not seem fully sentient."

Well, I reckon I got to light out for the territory ahead of the rest because Aunt Sally she's going to adopt me and civilize me and I can't stand it. I been there before.

—Huckleberry Finn, Mark Twain

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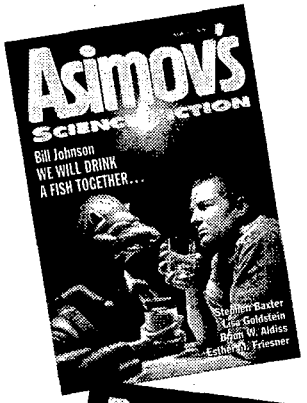

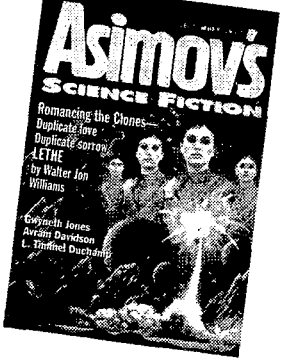

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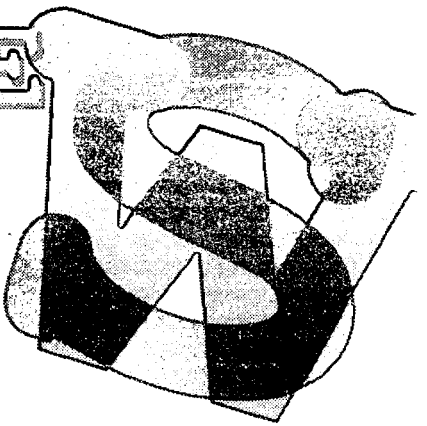
Lawrence Watt-Evans

REMEMBRANCE OF THINGS TO COME



Academic nitpicking is an exercise of little importance to the real world. Oh, yeah?

He stared at the student in shock. "You think it's a *typo*?" he said.

"Well, yeah," the boy said, shifting his weight nervously from one foot to the other. "W is right above S on the keyboard; it'd be easy to type 'wet' instead of 'set.' And 'set' makes a lot more sense, doesn't it?"

"No," Williams said, his voice not entirely steady. "It changes all the imagery completely, don't you see that? 'He wet the blade on the floor' is the essential clue that he's killed her, that the floor's covered in her blood. . . ."

"So maybe it isn't," the boy said. "Maybe she really *is* asleep, and he's decided to forgive her."

"But that's a completely different story!"

The boy shrugged. Williams stared at him in horror—didn't this smartass kid realize what he was trying to do? Williams had built his career on the careful analysis of Dorrie Ledbetter's short stories—hell, he'd written his doctoral dissertation on this very story, "A Sleeping Kiss," and had used it in class as a model for all his students to follow! His whole reputation had been founded on it. And now this . . . this *punk* dared to suggest that all the subtleties Williams had read into the story, based on that one final image of the protagonist wetting his knife in his wife's blood, were the result of a typographical error?

When the silence threatened to become awkward, Williams cleared his throat.

"It's an interesting theory," he said, "but for now, we'll just have to deal with the story as it was originally published, all right?"

The kid shrugged again. "OK," he said. "I just thought I'd ask. 'Set' seemed to make so much more sense."

"Well, things don't always make obvious sense," Williams said. "Now, run along, I need to lock up."

The boy turned, gathered his books,

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and trotted up the aisle, out of the classroom. Williams stared after him.

Then he pulled out his own battered copy of *Seven Endings* and thumbed it open to "A Sleeping Kiss" and began reading.

At supper that evening he poured out the whole thing to Dr. Garrand, his regular dinner companion. She was in the physics department, but pleasant company all the same.

"One word!" he said. "One *letter*, and it's an entirely different story!"

"That's fascinating," Garrand said. "A classic example of a sensitive dependence upon initial conditions. I'd never thought that would have applications in your field—though I suppose I should have; chaos theory certainly does seem to turn up everywhere once you start looking...."

Williams blinked. "Chaos theory?"

"Of course."

"Isn't that a mathematical thing? What's it got to do with literature?"

"It's mathematical in nature, yes. Chaos theory is a way of looking at systems too complex to predict by ordinary means...."

"What?"

Garrand sighed. "It's like this," she said. "In physics, or any other science, we look for models that will predict what will happen under certain conditions. Then we create those conditions and see what happens, and see whether our prediction is correct. If it is, that's good; if it isn't, we throw out our model and start over. But sometimes, there are things that are so complicated we can't say what will happen, even if our models are right. There might be a situation where the tiniest little fluctuation can completely change the outcome—the classic example is the flap of a butterfly's wing stirring the air at just the right time, in just the right place, to start a cascade. That one tiny movement means that a breeze is ever so slightly stronger, so a branch falls that wouldn't have, and that changes something else, and it builds up and builds up until you have a hurricane that wouldn't have happened if that butterfly hadn't been there."

"For want of a nail, the kingdom was lost."

"Something like that, yes," Garrand agreed. "Ordinarily, the flap of a butterfly's wing would be lost in the noise, canceled out by other events; but if everything's just right, it can tip the balance and change everything. That's a sensitive dependence on initial conditions—your starting set-up determines what effect that butterfly has."

"And that one letter is the butterfly."

"Yes!" Garrand nodded. "If the letter is W you have the story you always thought was there, about a grief-stricken murderer; if it's S, then you have a story of forgiveness and redemption."

"But how do I know which is right?"

"Well, if this were quantum mechanics I'd say you *can't* know, that the Heisenberg principle is in effect—but it isn't physics, it's literature. You can open Schrödinger's box and see if the cat's alive or dead by contacting the author and *asking* her whether she meant to say 'set' or 'wet.'"

Williams had no idea who Heisenberg or Schrödinger were, or what cats had to do with anything—Ledbetter hadn't been one of the Beat writers, she was after that. He did, however, understand Garrand's basic suggestion.

"Dorrie Ledbetter's dead," he said. "She died before the story was published, in fact. Heart failure, at age forty-seven."

"Oh," Garrand said. Her face fell. "Maybe her editor? Or her heirs?"

"I can ask, I guess," Williams said thoughtfully.

Two weeks later he and Garrand dined together once again after a longer hiatus than customary, and Garrand had to struggle to hide her dismay at Williams' appearance. He hadn't shaved for at least three days, and his hair, normally fussily neat, was uncombed. There were circles under his wild eyes.

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"You want to know something awful?" he said. "*Nobody* knows. I'm not sure *Ledbetter herself* really knew!"

"Well, of course she did," Garrand said soothingly. "She must have known what story she was writing."

Williams smiled crookedly. "You'd think so, wouldn't you? But I'm not sure. I tracked down the original manuscript, you see, and got a photocopy."

"So which is it in the manuscript?"

Wordlessly, Williams pulled a paper from his pocket and unfolded it.

Garrand leaned forward and looked at it.

"Oh, my," she said.

The manuscript was typed, not computer-printed—and the key word was spelled with *both* an *S* and a *W*, one typed over the other.

"And even the experts can't tell which one was first," Williams said wearily. "She used a non-correcting electric typewriter, and each letter was a single stroke, no white-out, no repeat. Maybe if someone did a microscopic fiber analysis of the paper, to see which fibers were stretched how by the impact—but Ledbetter's niece won't allow it."

"So you aren't the first person to wonder about this?"

Williams snorted. "No," he said. "But it's been kept quiet; the publisher doesn't like to admit they might have made a vital mistake in one of their reliable sellers."

"So nobody but Ledbetter herself ever knew which was the correct version?" Garrand asked, as she stared at the photocopy. "Huh. Or maybe *she* didn't know, either—maybe she planned it *both* ways. Maybe she wrote the story as a wavicle, a quantum indeterminacy...."

"What?" Williams stared at her.

"I'm sorry, I'm just babbling," Garrand said, as she slid back down into her chair.

"But you think she might have done it *on purpose*?"

Garrand shrugged. "Who knows? Maybe. Don't writers do things like that sometimes? Maybe she couldn't decide which version she liked better, and wanted to let it be determined by chance, like Marcel Duchamp and his standard curves."

"Or she wanted to let it be determined by the typesetter," Williams said morosely. "Making him an unacknowledged collaborator."

"She trusted the universe to make the correct decision," Garrand said. "Everything for the best, and all that."

"Ha!"

"Oh, come on; what's the problem? Everything will work out fine...."

"No, it won't!" Williams burst out. "Don't you see that? *I'll never know!*"

Garrand hesitated. "Ledbetter didn't leave a diary or anything?" she asked. "No correspondence with her editor?"

Williams shook his head. "Nothing," he said. "She was sort of secretive; she liked to wait until everyone had had a chance to read her stories before she said *anything* about them. Except she died before anyone read 'A Sleeping Kiss.'" He sighed. "If only there were some way to go back and *tell* her to leave a note, that she wouldn't live to see this one in print...."

Garrand bit her lip. "You know," she began, then stopped.

"What?" Williams asked.

Garrand hesitated, started to speak, stopped again. At last she said, "There *might* be a way to tell her."

"How?" Williams demanded. "She's been dead for thirty years—are you planning to hold a seance or something?"

Garrand shook her head quickly. "No," she said, "not a seance. But we've been working on something in quantum physics lately...."

Williams stared at her. "A time machine?"

Garrand grimaced. "Well, not in the traditional sense," she said. "We can't send matter through time—that's not allowed under our current working model of spacetime."

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"Energy, then?"

"Energy and matter are the same thing," Garrand said.

Williams frowned. "What else *is* there, besides matter and energy?"

"Information."

Williams sat back in his chair and stared silently at her for a moment.

"OK," he said, "I give up. How do you send information without sending matter or energy?"

"We're back to Schrödinger's cat," Garrand said. "Let us suppose you have a particle that decays into two other particles, one with a positive spin and the other negative . . ."

"Never mind," Williams said, interrupting her. "I don't want to hear about any cats or quantum stuff. I just want to know what form this information would take. It can't be a piece of paper, or even a radio signal, right? So what would it be?"

"Memory," Garrand said. "We think we have a way to record the quantum state of a present-day brain onto a brain somewhere in the past in such a way that the patterns in the receiving brain will duplicate those in the source brain, and that as a result the receiving brain will acquire the memories of the source brain. And since memories and brain patterns are all we are, it'll be as if the personality of the present-day person were transported into the brain of the person in the past."

"What, you mean they'd swap bodies?"

Garrand sighed. "No," she said. "Not at all. The present-day person wouldn't change at all; the information is being *copied*, not moved. And the recipient ought to acquire the sender's memories and personality, but there's no reason the recipient's *own* mind would be affected. There's plenty of room in a human brain for two personalities and two lifetimes of memories."

"So it'd be like a split personality? Could they talk to each other?"

"I don't see why not," Garrand said.

"So you could send a copy of my memories back to her, to warn her?"

"That's the theory. The fact is, though, we've been looking for some way to test it, but we ran into a lot of ethical issues. . . ."

"But we want to *warn* her that she's going to die! Surely that can't be unethical!"

"Well, that would depend . . ."

"No, it *can't* be." Williams leaned forward across the table. "Don't you see? You've got to do it!"

Four days later, as Williams lay motionless on the slab and the MRI scanner slid over him, one of the other researchers leaned over and whispered to Garrand, "Warn some poet that she's going to have a heart attack? Why don't we do something *worthwhile*, like warn the crew of the Titanic that there's ice ahead?"

Garrand didn't bother to correct the misstatement of Ledbetter's chosen form; instead she shrugged. "This is safer," she said. "We don't know how much history might change if we did anything big. Even *this* wouldn't get past the ethics committee if we'd bothered to ask them."

"We didn't ask . . . ?"

Garrand smiled. "With great power comes great responsibility," she said, "but I don't think anyone's responsible enough to resist testing this thing at least a little, no matter what the rules say."

An hour later Williams sat up and reached for his shirt.

"Now what?" he said.

"That's it," Garrand told him. "Either Dorrie Ledbetter got a copy of your memories, or she didn't. Now we just need to find some evidence of which it was."

"What sort of evidence?"

"Whatever she remembers would get to you."

She woke up suddenly and stared at

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the ceiling, momentarily confused. She remembered lying on a platform in some sort of machinery—was that a dream? She was here, safe in her own bed....

But it wasn't her bed, was it? The ceiling was the stained and flaking ceiling of her boarding-house room, but she lived in a pleasant little apartment just off campus.

She blinked. Campus? Apartment?

She lived in a furnished room in a crumbling Edwardian disaster of a boarding house, with her cat and her typewriter, and here she was.

But she *also* remembered a sunny room on the fourth floor of an apartment house, a little kitchen on one side, a tidy little bedroom on the other, and that didn't come before the boarding house, before this she'd been in the basement apartment that always smelled of mildew, and before that she'd lived with her parents in the nasty little ranch house in Poughkeepsie—where did a fourth-floor apartment fit in?

She tried to remember. She'd taken the apartment when she first came to Queensbury College (she'd barely *heard* of Queensbury, had never been there!) right after the turn of the century, in March of 2001....

She blinked again and sat up.

It was 1978. She knew that.

But it was 2010, and she *also* knew *that*.

She looked around the room, at the digital clock and the faded curtains and the battered IBM Selectric. This was *definitely* 1978; there wasn't a computer screen anywhere in sight, and a typewriter like that would be a museum piece by 2010.

So why did she remember lying down in 2010, on a sort of hospital table surrounded by machinery? And how did she *know* typewriters would be obsolete, replaced by computers, by the turn of the century?

A dream was the only explanation, but it was one *hell* of a dream, to have this kind of effect on her! Usually the hard part was remembering dreams, keeping them from fading away, but this one seemed to be getting stronger with every second she was awake, trying to crowd out *real* memories.

She got up and pulled on her robe, then headed down the hall to the bathroom. She used the toilet, then stood and turned to the mirror. Her hand reached automatically for her razor.

She stopped dead. Razor?

Well, of course, she had to shave, didn't she?

Shave *what*? She'd stopped shaving her legs back in college, when she finally gave up any idea that she might someday play the ugly duckling and and turn out a swan instead of the fat pig she was.

What the hell was wrong with her? Why did she remember another face, a man's face, that ought to be in the mirror? Had she suddenly developed a split personality, like Sybil?

But Sybil's personalities hadn't confused memories like this. She *remembered* being male—and a very strange, uncomfortable memory it was. She reached up and touched her shoulders, her arms crossing across her breasts, then looked down at herself.

She was unquestionably female. Dorrie Ledbetter, age forty-seven, weight a mortifying two hundred and fifteen pounds, critically acclaimed but dirt-poor writer, teacher of creative writing at the adult education center six blocks east, where she was paid two dollars per student per hour to tell little old ladies that their inept moral tales of heroic pets and naughty children showed real promise but still needed work.

But she remembered so *very* clearly being Richard Williams, assistant professor of English at Queensbury College, several inches taller and only slightly overweight, with a potbelly that he knew he could eliminate any time he was willing to work at it a little.

This couldn't be a premonition; she

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didn't believe in them, for one thing, but for another, how could she foresee being someone else? And a member of the opposite sex, at that—she wasn't one of Le Guin's Gethenians, able to choose her role; she was a woman, and would always be a woman.

Was this some bizarre hallucination? A flashback to her one experiment with LSD, back in '69, perhaps? It didn't *seem* anything like that experience of crawling colors and time distortion; the sink looked completely normal, white porcelain with greenish stains around the drain, and time seemed to be ticking past at the usual rate.

She was Dorrie Ledbetter—she had Dorrie Ledbetter's body and was in Dorrie Ledbetter's room—so why did she remember being Richard Williams?

What exactly did she remember? She leaned heavily on the sink and tried to think.

She had eaten alone the night before, sat up late reading, and gone to bed. But what had Richard Williams been doing last night?

She remembered lying on a table in a laboratory, and this huge machine like something out of "2001" moving across her. An MRI scanner, Garrand had called it . . .

And that was absolutely her last memory of Richard Williams; that was what had woken her up this morning, the memory of lying there while her/his memory was copied.

She'd been sent a copy of memories from the future.

Her mouth fell open, then snapped shut.

That was crazy; that was science fiction.

She stared at herself in the mirror.

Richard Williams had wanted to know what she'd meant in one of her stories, so he'd sent a copy of his memories back in time, into her sleeping mind, so she would leave him a message.

And why did she need to leave him a message? Because she was about to die! She wouldn't live to see "A Sleeping Kiss" published.

She turned and stared out the bathroom door at the table against the wall, the little table where a manila envelope stood propped up, waiting to be mailed—an envelope containing the manuscript of "A Sleeping Kiss."

"Oh, fuck," she said.

Then it sank in, and she shouted it. "Oh, *fuck*!"

She was going to *die*, and this callous bastard Williams had told her about it *just so he could find out what she'd meant in one of her stupid little stories?*

She gripped the edge of the sink and steadied herself.

Wait a minute, she told herself. Just wait. Think about this. Memories from the future? And she *believed* that?

Well, she *had* to. The other possibility, that she was imagining the whole thing and was therefore going insane, wasn't any better.

And what kind of an imagination could it possibly be that would spring this on her all at once? Why would these memories all appear full-blown like this? She could remember what it felt like to be a man—and a nasty memory it was, too. She could remember the Gulf War, and the huge celebrations at the turn of the millennium, and the fall of the Berlin Wall, and the Challenger explosion . . . how could she have made all that up overnight?

Something she—no, Williams—had said came back to her. "So it'd be like a split personality? Could they talk to each other?"

"Hello?" she said. "Anyone there?"

No one answered; no little voice spoke up in her head. It appeared Garrand had been wrong. If she were a split personality, suddenly manifesting this new, invented identity for the first time—which didn't *at all* fit her understanding of how MPD worked, in any case—then why would *she* have all of Williams' memories?

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No, Garrand had been wrong. The memories were *not* the personality. Her brain was still entirely hers; she just had a lot more jammed into it now.

And it must be real. No other explanation made sense.

After all, why *shouldn't* someone invent something like this, someday? Apollo 11 must have seemed just as unlikely to her parents.

So Williams' memories were true. And she knew the future—or thirty-two years of it, anyway.

But she wouldn't live to see it.

"Well, screw *that*," she said, looking in the mirror again. "And screw *you*, assistant professor Richard Williams! You selfish, self-centered, egotistical, petty *bastard*! Why the hell should I care whether *you* know what my story's about?" She stamped out of the bathroom, crossed the room, and snatched up the envelope, tearing it open.

She had to see whether she really had typoed that word; she hadn't caught it.

And if she hadn't, then she'd need to retype the last page; she couldn't expect to get the *S* and the *W* lined up properly if she just put the existing one back in the typewriter. She'd make *sure* that son of a bitch didn't know which she'd intended, not unless she was still alive to tell him!

She found the right page and scanned it. No typo. She'd had it right.

She began tearing the page into little pieces, which she would burn at the first opportunity; she could copy the carbon, and then she'd destroy *that*, too.

For a moment she considered destroying the entire manuscript—but she needed the money, especially now that she *knew* it would sell the first place she tried it, and besides, she wanted Williams to experience that horrible moment, years from now, when that smartass kid would point out the typo.

She sat down at her desk, sandwiched carbon paper between two fresh sheets of mimeo bond, and rolled them into the typewriter.

"Forewarned is forearmed," she muttered to herself as she typed "Ledbetter/Kiss" and the page number at the top. "A heart attack, huh? Because I'm too goddamn fat? OK, you son of a bitch, then I'll stop being fat! You think I can't? You think just because I'm a woman I'm too passive and stupid to do something about it? I'll *live*, you bastard, and what's more I'm going to be rich, because *now*, you moron, I know what's coming! I'll bet on Reagan in 1980, I'll bet against the '86 Red Sox—thank you, Bill Buckner! I'll invest in Intel and Microsoft. You wait and see, Williams—one day I'll show up on your doorstep and spit in your face!" She snorted derisively as she rapidly typed through the next sentence. "You went and wasted this on my stupid *story*? You didn't warn someone about Adolf Hitler, or Pearl Harbor, or Vietnam? Someone gave you a time machine, and all you want to do is *fix a typo*? Jesus, that's like, I don't know—destroying the planet to send a message, or something. You don't want to interfere, my ass—God, you *deserve* to suffer!"

She slowed, and carefully typed "set," then backspaced and typed a W over the S.

"There," she said. She spaced forward and continued typing.

Water and celery, she told herself silently. She would live on water and celery until she'd lost fifty or sixty pounds. She'd been meaning to lose weight for years, she'd known she ought to lose ninety, maybe even a hundred pounds, but she could never force herself to diet and exercise—it wasn't as if she'd had all that much to live for, after all.

But now—now she knew she'd be at least moderately famous. Now she knew she could be rich. With *that* for motivation a few weeks of starvation would be nothing.

She laughed to herself as she typed "The End" at the foot of the page.

"I'll show *you*, Dickie Williams!" she said. She ripped the page from the type-

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writer, and rummaged in the drawer for a new manila envelope.

Ten minutes later she dropped the envelope in the corner mailbox and jogged, panting, toward the park.

The medical examiner shook his head. "Damned stupid fad diets," he said, tossing the folder on his desk.

The police lieutenant glanced at him.

"This Ledbetter woman," the ME explained. "She hadn't eaten a decent meal in weeks! She was living on carrot sticks and water. Lost forty pounds, sure—but the strain on her heart was too much." He leaned back in his chair. "She couldn't afford a doctor—I guess no one warned her just how risky a crash diet like that can be!"

"She was still pretty hefty," the lieutenant remarked. "She must've been really something, if she'd lost forty pounds."

"Yeah," the ME agreed. "She might've had the heart attack anyway." He shrugged.

"I guess we'll never know," he said.

"I can live with that," the lieutenant replied. ■

IN TIMES TO COME

Our May issue begins a new serial by Catherine Asaro, *The Quantum Rose*, with cover by George Krauter. It's set in the same universe as some of her books but you need no prior familiarity with them to understand and enjoy this one—though it may take you a while to realize just what you're seeing. You might, initially, even mistake it for fantasy; but nothing could be further from the truth (remember "Clarke's Law," and bear in mind that the same thing can look very different from different points of view!). For now, let's just say that there are parts of our history we'd like to think we've left far behind us—but new developments in our future may bring them back in new and even more sinister forms. . . .

In our science fact article, Stephen L. Gillett, Ph.D., looks at an old standby of popular quasi-science: the speculation that, somewhere out beond Pluto, lies a tenth planet. *Real* science is now finding that there are not one, but a *lot* of additional objects Out There—hence Dr. Gillett's title, "Planets X." Last but by no means least, our fiction line-up also includes a new Mars novella from Ben Bova and a novelette by recent Hugo winner Bill Johnson.

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Probability Zero

GOING HOME

H.G. Stratmann

Tony Phineus, commander of the first starship, grinned at his sole crewmate on the *Perseus*. "Ready to go home?"

Polly Dectes, the vessel's astrophysicist, settled into the chair beside him at the control console. "The real question is, *can* we go home again?"

Tony snorted. "Always the skeptic." He pointed to a monitor showing Tau Ceti, a warm golden orb burning one-point-two AU away. "We've proven the Lyndore-Gradle drive works perfectly. Flip a switch, blink—and you travel as many light years as you want!"

Polly frowned. "True. But I can't help remembering all the arguments twentieth-century physicists made about why superluminal travel and communication were impossible. The cause-and-effect and time travel paradoxes they might create. If you could transmit a signal faster than light, someone else could receive it and send an FTL reply back telling you not to send it—before you even sent the original signal! But if you decided then not to transmit the signal, how could anyone send you that reply not to transmit it?"

"Obsolete theories. Fine in their day, like phlogiston and epicycles. *This* is reality!"

Tony flipped a switch. Now the monitor showed the planet whirling serenely below them—a brilliant symphony of azure oceans, brown-and-green continents, and writhing serpentine clouds. "Size, gravity, temperature, atmosphere—all similar to Earth. And the mobile probes we sent down showed only Devonian-level life. No harmful bacteria or viruses."

He gazed wistfully at the screen. "Too bad we're not equipped to land there. The *Perseus II* will need landing shuttles and a team of biologists to go down and confirm the planet's safe. Then the human race will really have a 'New World,' ready for colonization!"

"*If* we get back and tell them what we found."

"Why wouldn't we? The *Perseus* returned to Earth orbit right on schedule after all eight unmanned automated flights to Tau Ceti. And the lab mice onboard were perfectly healthy."

Tony pointed to the console. "When I flip that switch, we'll go home too . . . instantaneously!"

"I hope so. But nobody really explained why the computers and recorders didn't contain any data after all of those test flights. No information at all about this star system or what was in it. It's almost like Nature didn't want us to know something."

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"Ed was satisfied it was a software glitch. Or maybe a problem with the sensors."

Polly sighed. "Yes. But I suspect our illustrious boss was more interested in talking us into going and keeping his precious project funded than he was in our safety."

Tony waved his hand at her impatiently. "This time, we *know* our equipment collected data. Even if their electronics got fried, there're still all the voice and video recordings we made. Plus everything we wrote in our notebooks."

He scratched his nose. "Besides, *we* remember what we found here. One way or another, the people back home will learn everything we know about the Tau Ceti system too!"

"Maybe, but—"

Tony ignored her. "Earth, here we come!" He flipped a switch—

The fluorescent light in the ceiling above him flickered on. Tony stared upward at the IV bag hanging beside his hospital bed.

Suddenly two faces hovered above him. Ed Minor, director of the FTL Project. And a middle-aged woman in a white lab coat.

"Any change, doctor?"

"I'm afraid not. We still haven't found any medical explanation for why they're like this. Was there anything on the ship to indicate what happened to them?"

"No. It was just like the test flights. No data in the ship's computers. And they didn't make any audio or video recordings, or write anything in their notebooks. The only way to find out if they made it to Tau Ceti and what they found there is for them to tell us. The ironic thing is, the mice on the *Perseus* came back perfectly fine again. But *they* can't tell us what they saw or heard."

Ed's voice grew desperate. "You've got to help them, otherwise the whole project will be shut down! Maybe if we put them on the ship and sent them back to Tau Ceti, the shock would snap them back to normal!"

Tony's brain screamed, *Yes! Send us back there, where we can't talk to you!*

The doctor sounded outraged. "That's ridiculous! I won't let you endanger my patients! They'll stay right here!"

Tony tried frantically again to make his lips move. Maybe signal to them with a curling finger or toe, a fluttering eyelid. But his limbs stayed flaccid, eyes fixed and unmoving.

Ed whispered, "Can he hear what we're saying?"

"Probably. Their condition isn't a true coma, but resembles a 'locked-in' state. I think he can hear and see normally. He just can't move or communicate with us."

"Isn't there anything you can do?"

"We'll give them the best care possible. Maybe, someday, we'll find a treatment—or they'll recover on their own."

Someday. Tony imagined what Polly would say if she could speak. "Nature lets you travel, but not *communicate* faster than light. The Tau Ceti system is eleven-point-eight light-years away. Anyone on Earth can only know what it was like there eleven-point-eight years ago. If a person travels to Tau Ceti faster than light, then returns to Earth intending to tell other people what he or she saw there—"

Maybe the universe wasn't totally heartless. Each passing second made what he and Polly knew less prescient relative to everyone else on Earth. Perhaps, when the rest of humanity eventually "caught up" to where the two of them had jumped ahead on Nature's inflexible timeline for information, the delayed paralysis caused by gazing at that Medusa-like world orbiting Tau Ceti would suddenly disappear.

A speck of dust drifted onto Tony's nose, leaving a terrible itch that wouldn't go away. He stared upward, petrified, at the featureless white ceiling and steady drip of fluid from the IV bag.

It was going to be a long eleven-point-eight years. ■

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Michael F. Flynn

PRUDENCE AND FORTITUDE

There are many barriers between us and the stars—and the aren't all Out There.

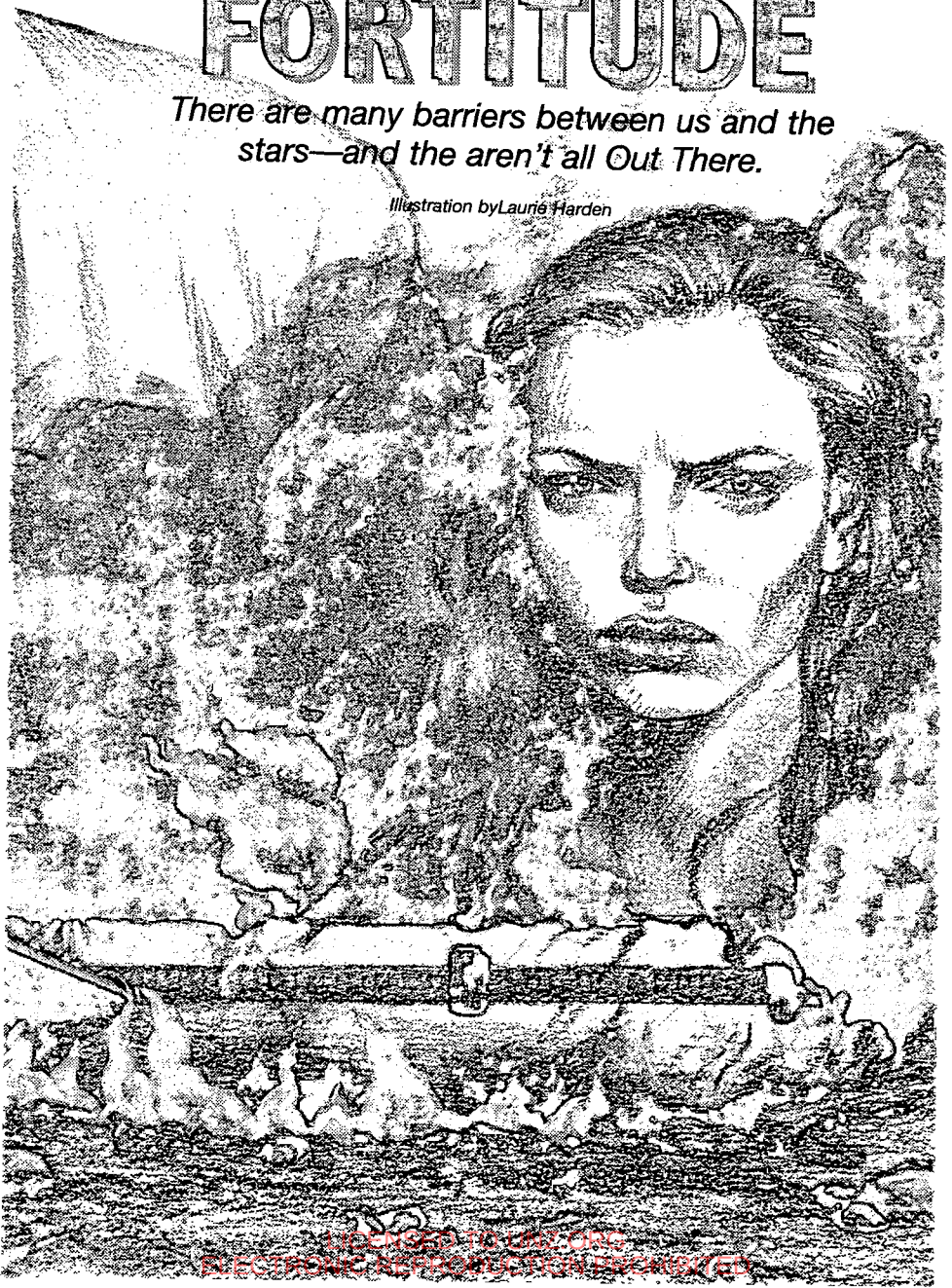

Illustration by Laurie Harden

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I. Prudence

It had been a lousy day from the get-go and there weren't enough hours left for it to get any better. The Boeing 717 banked and dipped into the turgid cloud layer shrouding the LA Basin. Jacinta Rosario worked imaginary pedals with her feet and treated the tray table as a surrogate yoke. The night sky outside the windows was swallowed by haze and Jacinta looked past the curve of the wing, hoping to see the matching constellations of the Greater Los Angeles Area spread out below.

No such luck. It looked like haze all the way down. She tried to imagine what the pilot would do next; tried to feel the motion of the plane the way the pilot did. *Absorb Care into the Task,* the Seventh Precept read. If she *became* the airliner, she could forget that she was out on her own and how difficult a path lay before her. *Initial descent,* she decided. It didn't feel like another loop around. They had broken the holding pattern—at last!—and were making their approach.

"We're starting our final descent into LAX," the chief steward announced over the speakers and Jacinta smiled over her small triumph. "Time to pack things up, folks. The weather down there is overcast and raining, so it'll probably be a little bumpy going in. We're sorry about the delay, but ..."

But it's not our fault. Jacinta stopped listening. She'd heard three thousand miles of excuses masquerading as apologies, and that was enough for her, thank you very much. Who *cared* whose fault it was? It was just bad luck. Snow in Newark had forced her to wait: for the equipment, then for the flight crew, then for a departure window. It was somehow fitting that a late Pacific storm would delay her arrival. What it all added up to was: she had missed her connection to Bakersfield. It would be easier—certainly more comfortable—if there were someone to blame; but the only candidate in sight was God; and He, by the evidence so far, was not paying attention. Well, the Twelfth Precept was: *Fix the Problem, not the Blame.*

The postures of the other passengers expressed weariness, boredom, or irritation. For most, Los Angeles was a destination, not a connection; so it didn't matter if they were a couple of hours late. She sighed, gathered her papers, and stuffed them into the flight bag under her seat. The man in the aisle seat beside her glanced her way.

"Something pretty important, I guess; the way you've been studying them."

Over and over, the whole long flight out. They read the same each time; but her heart soared too each time she read the words. Was her spirit that obvious? Jacinta set her face into more composed lines while she sized him up. Mid to late sixties, she guessed. Carrying more pounds than he ought to. He'd spent the whole flight from Newark reading Westerns, so he was no great thinker. On the other hand, he didn't sound like someone coming on to a seventeen-year-old woman traveling alone. It was the forty-somethings you had to look out for.

"Yes, sir. Pretty important." The man raised his eyebrows at the 'sir,' but he didn't make a fuss about it one way or the other, so she added, "I'm starting at Glenn Academy for the spring term."

The man nodded. "Good for you. Bucking for space pilot? I hear the competition's real fierce."

"Yes, sir." She smiled for him. "But so am I."

Fierce but frightened. She had never been so far from her sisters before. What happened when you missed a connection? Did the airline make arrangements? Was there another flight they could put her on? Who should she ask? She walked off the jetway into the waiting area, trying to look confident. It was the Lost Lamb that attracted the predators.

Maybe she looked too confident. No one came to offer help. *You're eighteen*

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years old. Almost. An adult. What was it the grownups liked to say? Just Do It. Of course, grownups didn't have *Precepts,* just slogans, but sometimes they managed to capture a truth. Twin TV screens listed arrivals and departures, and she drifted over to them. So many departures were listed as DELAYED that for a moment she dared hope her Bakersfield flight was still on the ground. But, no . . . Gone. Departed. Adios, señor airplane.

"There's a later flight," a male voice said over her shoulder.

She turned to scowl at a dark-haired boy her own age wearing a sheepskin-lined leather jacket. Fake sheepskin, she hoped for his sake. "How would you know where I'm going?" she said in the Voice of Polite Distance.

"He doesn't even know where *he's* going," said the young woman with long, blonde hair and strikingly violet eyes who stood beside him. She wore a gimme cap in Aurora purple with gold thread spelling out *RS-135 Neta Snook.*

"Chaos theory," said the boy agreeably. "In an ultimate sense, none of us know where we're going. Too many variables over too many years. But in the short term, precise predictions are possible. Bakersfield. Glenn Academy." He smiled broadly. "Right?"

The blonde woman said, "Stickers of SSTOs and Black Horses all over your flight bag was Sherlock's subtle clue. Hi, I'm Ursula Kitmann and cutey-pie here is Soren Thorvaldsson. We're cadets, too. Just met on the flight out here. We were on our way to the commuter gates when Soren noticed you."

"Hey," said Soren. "Worth noticing."

Jacinta accepted the outstretched hands in the Posture of Possible Friendship. She explained about the storm in Newark. "Tell me about it," Soren complained. "I came from Minneapolis, where it's clear as a bell. But the *plane* I was supposed to come in on was held up in Atlanta because its *crew* was waiting in Chicago for another plane that was stuck in Boston."

Ursula shrugged and said, "Same story, different cities. The air traffic system's stacked like dominoes. One local foo and the whole thing dominos."

"So," said Soren, "we're all in the same boat—I mean, in the same plane. If—" A nod toward the flight board. "—we can wangle seats on the Midnight Special."

"Which is way over in the commuter concourse," Ursula added. "We've got plenty of time, but the sooner we get there, the sooner we can confirm seats. It'd be a hell of a thing to get this close and miss First Muster. They can give your place away if you're a no-show. Did you know that?"

Of course, she knew that. Hadn't she read and reread the admission papers for the last few hours? She didn't think an air-traffic foo would count against her; but she had come too far to be turned back. Since the other two clearly knew their way around airports, Jacinta followed them down the concourse. Yet, it would be so easy to throw her anxiety on their shoulders; to accept their lead. *You are not a duckling. You do not imprint. Stand beside; never behind.* The recitative comforted her and she quickened her pace to walk next to Soren. "Have you been here before?" she asked. "This airport, I mean."

Soren's locks danced when he shook his head. Ursula only shrugged. "Every time mom and dad traded me off," she said. "Until they decided which of them didn't want me more than the other." She closed her mouth abruptly and frowned, as if she had said more than she had intended. '*Knowledge grows from experience,*' Jacinta thought, '*not from superiority; but experience always has a price.*'

At the gate for the Bakersfield flight, they found four frazzed businessmen, a cheesehead, a woman shepherding a pair of unruly todds, and three more cadets. There were plenty of seats available, as it turned out. Cancellations, failed connections, and no-shows had opened up enough spaces to accommo-

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date them. The checker-in told them the flight was on hold until eleven-thirty, but that could be lifted at any time if a crew could be gotten. There was a thunderstorm in the mountains, but it looked to be breaking up.

Ursula groaned. "An hour and a half?"

"Law of Averages," Soren told her with his infectuous smile. "We were late for our scheduled flight, so we're early for this one. On the average, we're on time. Hey, 'Cinta! If they need a crew ... Do you have a jump jet licence?" He grinned and Jacinta could not keep an answering smile from briefly surfacing.

The businessmen exchanged arcana about stock markets and system audits; and the cheesehead had his induction cap on and was pondering his laptop. The other three cadets introduced themselves. The willowy girl with the elfin face was Marta Molnar. She had flown all the way from Budapest, and spoke with an oddly pleasant accent. Square-jawed Jason Holzstreicher had a solid but unfinished look, as if he had been whittled casually from a log of white ash. Alonzo Sulbertson, who was medium height, slim and black, was a lordly third-year student. The gold-and-ruby pin in his collar proclaimed him a veteran of at least one orbital training flight. That alone marked him a demigod.

Experience, not superiority, Jacinta reminded herself. Prudence, temperance, knowledge, and fortitude would one day win her a brooch like that one.

It was natural that they klatsched. Six young men and women sharing a common dream? How could they not? Mutual attraction, like gravity, drew them into a circle. They perched on the chairs or squatted cross-legged on the floor. Every now and then the laughing three-year-old dodging her weary mother would break through the ring.

Molnar spoke with the worldly cynicism of the European—a jaded attitude that Jacinta recognized as False Confidence. Kitmann was quiet and reserved, occasionally sarcastic. Jacinta noticed the small, discreet pin on her collar—the Dove Within the Sun—and adjusted her own scarf to display the Silver Apple; but if the other sister noticed, she gave no sign, and custom required that one not be forward about such things.

Holzstreicher exuded a confidence in voice and body language that bordered on arrogance. The Macho Man. Like Soren, he had a pilot's license already. He spoke loudly and interrupted inappropriately and deferred only when the quiet Sulbertson spoke, which was seldom. Jacinta noticed that Soren, otherwise sassy and ready with oddball jokes, also deferred to the upperclassman. *Alpha male*, she thought, studying the black man. *At least a local maximum.* Sulbertson—sensing her gaze?—glanced at her and Jacinta withdrew her attention.

They were, Jacinta realized, perilously close to bonding; and she wasn't sure she wanted to do that with a random group of people she had barely met. *Choose your friends*, she recited to herself, *as you choose your foes, for both you will keep for life.* She shifted her posture slightly, creating distance, and passed more often when the verbal buck came her way. Sulbertson may have sensed something, because she caught him casting curious looks her way from time to time.

As the Observer, she found her attention drawn more and more to Soren. The Minnesotan, like the others, was her age within a year or two; yet, he seemed younger. Maybe it was his eyes or his baby-faced good looks. Maybe it was his openness. Maybe it was his terrible jokes. ("I need to borrow your brain," he said to Sulbertson at one point, "but I promise to give it back.") But gradually she became convinced that he was closer to his center than any of the others, except perhaps Sulbertson, whose extra years gave him some additional anchorage. Usually, the Joker masked insecurity. Molnar's continental urbanity certainly did. The Hungarian girl, half a world

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away from anything familiar, shouted loneliness with her very posture, even while she smiled and chatted. But when Soren made a bad joke, it was not simply to draw attention. He made bad jokes because he knew they were bad and found humor in that badness. The second derivative of humor in the calculus of laughs. There was something in his mind that saw and pounced on juxtapositions, and made quirky connections. He was altogether the most attractive of her chance companions.

Realizing that, Jacinta stood abruptly. "I'm hungry," she announced. "Anyone want a hot dog or something?"

Head shakes and nods. Holzstreicher said, "Get me a Coke." Sulbertson pulled a ten from his pocket and said, "My treat. Dog and a coke. Ketchup on the dog."

"How much ketchup?"

"Put it on. I'll scrape off what I don't want. That's easier than working it the other way."

"I'll have a hot dog, too," Soren said, turning his deep, dark eyes on her. "Nothing on my dog, please. I like my nitrates straight up."

"Watch my flight bag, wouldja?" She hadn't asked anyone in particular, but she noticed as she walked away that it was Soren who pulled it closer to him and was annoyed to find that that pleased her.

The snack bar was a short walk down the concourse, set in a narrow niche in the wall. The SPP grating had been pulled half-shut, as if to announce imminent closure, but the owner had shown pity for the stranded travelers. Jacinta was not the only one who squeezed inside with a late-night snack in mind. There were two lines, each several customers deep, and Jacinta took her place in one. A portly, balding, sixtyish man and a younger woman wearing a headband around raven-black hair serviced the customers. The television showed the Weather Channel—everyone's topic of interest, it seemed.

The lines inched forward. The buzz of conversation, the cheerful chatter of the weather channel, the occasional cluster of gate announcements blended into an inarticulate background. The time-lapse on the 3V monitor showed the downpour as it tracked across the LA basin, broke up, and retreated sullenly toward the northeast. The virtual POV rotated and moved through the storm cell up into the hills, turned, and came back through from another direction. Then coverage shifted to the Pacific Northwest and the conversation in line shifted to bitching and moaning about missed connections and late departures. Jacinta tuned them out.

She reached the head of the line and the bald man asked her what she wanted, but the black woman said, "Let me take this one, Carl," and traded places with him. The woman—Jacinta judged her to be nearly thirty—brushed some sweat off her forehead with the back of her wrist.

"A service, sister?" she asked.

Startled, Jacinta looked closer and saw the silver apple pinned to the woman's blouse. She didn't know why she was so surprised. Though most of their retreats were in the Northeast, silver apples could be found across the country. As the First Precept read: *The apple is never far from the tree.*

"Are you stuck here overnight, sister?" the woman asked in the Voice of Intimacy in Public.

"I don't think so. My flight's on hold; but we'll be going out in a little while. To Bakersfield," she added. "I'm Jacinta Rosario from the North Orange Retreat. I'm starting at Glenn Academy this spring."

"Make us proud," her sister said. "Fledgling?" Jacinta nodded. "This weather could change any minute," the older sister told her. "If you do need help tonight, you know our edress. I'm Darlene. We have a retreat nearby, in Torrance. One call and we'll come get you."

Jacinta would rather die than ask help on her fledging. The sisterhood taught

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that the hand was always open and always ready, but there was an unspoken stigma on those who reached for it too quickly. Dependency, even on one's sisters, was a last resort. She answered formally in the Voice of Independence. "I will remember your kind offer." Darlene nodded, as if in approval, then turned away to fill her order.

Jacinta made her way back to the gate more confident than she had been since the bus had stuck in the snow on the way to Newark Airport. She and Darlene had exchanged only a few words; yet she felt closer to the sister than to any of the young cadets she had shared the last hour with. Not that she disliked Kitmann and the others. They seemed decent enough; though the black man had a certain dangerous sleepiness to him. The Drowsing Panther. That might only be because he was older. And Soren was definitely shoog. What did grownups say? Buff? No, not "buff." "Dreamy," maybe. He had that unfocused, boyish look. Grownups probably tousled his hair all the time. *Remember this Type, sisters. The Little Boy. It will call on your mother-instinct.*

But did mothers feel this way, Jacinta wondered, about their sons?

It was a shock to find the waiting area empty and the plane gone.

She stood dumbly with the cardboard tray in her hands and surveyed the lounge. Gone. All of them. Her flight bag, too. Even the podium was closed down. The marquee announced DEPARTED in red, running capitals under the flight number and destination. DEPARTED ... DEPARTED ...

The drinks on her tray toppled and fell, creating a fan of Coke and ice across the tiles.

Alone and friendless, three thousand miles from home. Everything she had was in her flight bag; everything that had not been shipped ahead. How would she get to the Academy now? She would be late for First Muster and lose her place. She could feel the tears work their way like sap up her trunk; and she clenched fists over her bosom, opened the palms like spears, and called upon her Inner Strength.

There would be a flight out in the morning; but she would need someplace to spend the night. Not a hotel. Her cash card had gone with her flight bag. *Stupid!* The retreat? Surely the sisterhood would not hold her to blame if she sought refuge this one night?

No; though they might cluck to themselves outside her presence. Perhaps she wasn't ready to fledge, they would say. Never aloud, but the thought would be there. Her hand touched the jacket pocket where she carried her copy of *The Precepts of Mother Smythe. Dependency is the only sin*, she recited silently. *"It's not my fault," the one, true failure.* Slowly, calm returned. What can *I* do *now*? That was the key question. The only question.

The hand on her shoulder broke her concentration and caused her to suck in her breath. "Looks like we got a problem."

She turned, assuming the Posture of Readiness. A predator spotting a young girl alone; Sister Darlene coming to see her off; Soren having stayed behind when she didn't make it back in time ... Expecting anything, she did not expect what she saw.

Lonzo Sulbertson, the third-year student, had his own flight bag over his shoulder. Dark eyes lodged in a dark face; black hair cropped nearly bald. His broad, turned-up lips blending into his coloring, so that he seemed almost a man without features. Until he smiled and the white of his teeth showed.

"Looks like we both missed the plane," he said.

"Wh ..." She would not blubber in front of a man. It triggered the Guardian in them. Another moment passed before she could trust her voice. "What happened?"

"They lifted the hold all of a sudden;

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but it was a short window—too many flights backed up—so they couldn't wait. Doesn't take long, getting those little commuter hover jets boarded and out. Didn't you hear the announcement?"

The acoustics had been poor in the snack bar; the speakers had not been clear; the weather channel announcer had drowned it out; she had not been listening closely. The world was full of excuses. "No," was all she said.

"That kid, Thorvaldsson, ran down the concourse, but he didn't see you in line."

"There were two lines," she said, "I was in the back." *He didn't look hard enough. He should have checked*... But, no; she wouldn't play the Blame Game.

Sulbertson shook his head. "Tough luck. Got any plans?"

Instantly, she drew into herself. "Sure."

"Yeah." Sulbertson looked uncomfortable and glanced away for a moment. "Look," he said, "when I missed the plane I went to the pee-phones and rezzed a car. It's a fair drive over the mountains, but it's doable. If we start now, we'll be at the Academy not much later than the others. They'll still have to get a cab from the airport down the Fifty-Eight toward Tehachapi. This time of night, that won't be easy."

"We?"

He shrugged. "Long drive. Goes faster with someone to talk to."

"My flight bag's gone."

"Yeah. Thorvaldsson took it with him, like he was guarding it with his life. What're you getting at?"

She crouched and began gathering up the spilled food. *The consequences of your own actions are your own responsibility.* "My cash card was in my flight bag."

He gave her a puzzled look. "And ...?"

Jacinta sucked in her lip. "I can't help pay for the car."

Sulbertson squatted, too, and began helping her. He picked a hot dog off the floor and studied it for a moment before passing it to her. "Didn't ask you to."

"Then I'll help with the driving."

"In the dark and the rain and you don't know the roads over the San Gabriels ...?" He waved a hand. "Don't worry about it."

She stood with the tray of trash and dumped it in a nearby can. "I don't want to owe you."

He cocked his head and his smile faded. "A little fussy who you accept favors from?"

Her chin tilted up. "Yes."

"Like a black man?"

"It's not that. I just don't like to owe people."

"Get used to it," he suggested. He turned to go.

"Wait."

"What?"

"How come *you* missed the plane?"

He shrugged and dropped his glance. "Well. You know. I was ..." He jerked a thumb toward the rest rooms. Jacinta shook her head.

"That's damn good eyes, Sulbertson, if you saw Soren take my flight bag aboard. You had to be right here in the waiting area when they boarded."

"All right, I was. So what?"

"So you stayed behind on purpose. Why?"

"Why?" This time his smile seemed amused. "'Cause I gave you the money for the dogs and I wanted to get my change back."

It was an unlikely answer, and Jacinta wondered what she was getting into as she followed him down the concourse. Had he seized an opportunity to be alone with her for the long drive? He moved with easy, languid strides. How easily he had taken charge! Some men had a sense of lordship, as if all they surveyed was in their gift. Even when they didn't exercise that right, the *posture* of ownership was there, informing their actions.

The rain had started up again by the time they were northbound on the 405.

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The windshield wipers on the Ford Wraith slapped like a metronome—a lulling sound unsuited to a long night drive. Jacinta wondered why, with all the technological changes cars had gone through—on-board navcomps, heads-up displays, modular engines, aerogel bodies that gave strength *and* lightness—they hadn't found a better way to keep the windshield clear of rain and snow.

They had driven mostly in silence, if you didn't count the navcomp's voice whispering cues and warnings in seductive, androgynous tones. Jacinta sat closed in on herself, pondering the fact that she was alone, without resources, with a man she had barely met. From time to time, she glanced at him and saw how easily he sat. Both hands on the wheel, watching the road ahead, but with a casual manner. Totally in charge. Finally, he caught her looking.

"If I wanted silence for the ride," he said, "I could have asked Harpo Marx to tag along."

"Who?"

"Never mind." Sulbertson focused on his driving again and another few minutes went by. Then he said, "Is it me?"

"You what?"

"Making you so uncomfortable. You sit like you were carved from wood. 'Bout as talkative as a log, too."

Rain crawled like worms down the side window, creating strange, jewel-like sparkles each time they passed a streetlamp. "No," she said, lying only in part. "Just . . . the circumstances. Everything has gone wrong on this trip."

"Everything?"

"Do you want the list?" Start with all the things she had forgotten to pack. No. Start with all the people who hadn't come to see her off. Her sisters had come, yes; but *only* her sisters. Mom hadn't approved of the silver apples, called them 'a cult,' but did her disapproval have to run so deep that she would not even come to the airport to see her daughter leave?

"Prepare to merge with northbound traffic from I-Five," the navcomp murmurred. Sulbertson grinned. "Thanks, darling." He looked around—at the road ahead and behind—then his eyes came her way again. "So you're not always so stand-offish. Is that what you're saying?"

"I don't know what you mean."

"I mean the little walls you build between yourself and everyone else. Earlier, with the rest of the cadets, I could almost see you laying the bricks."

Jacinta crossed her arms. "You could see that, could you?"

"There. You're doing it again. With your body language and your tone of voice. It's like you're putting yourself somewhere else. I couldn't put my finger on it earlier, but that's it. You're frightened and alone and—"

"I am *not*!"

Sulbertson jumped a little. She had used the Voice of Independence. This time when he peered at her, his eyes were narrow and thoughtful. "And you're doing it on purpose, aren't you?"

She had parted her lips to tell him it was no business of his when the navcomp interrupted.

"Bulletin," the Voice sang cheerfully. "Emergency route change. Prepare to exit on the Fourteen in one mile. Recomputing travel times . . . ." A right turn arrow with the legend "One Mile" appeared in the heads-up display on the lower windshield and began to blink.

Sulbertson frowned and punched the traffic bulletin button on the console. " . . . combined with slick roads and fog, causing the chain-reaction accident on the Grapevine," announced the synthetic voice. "Traffic is stopped in both directions." Then, after a pause: "California Highway Patrol reports that—" Sulbertson cut the announcement off. "Damn," he said. "Hey, Navigator—that's you, Rosario—check the overview map. I think the new route takes us in the back way."

Jacinta leaned forward and frowned over the unfamiliar icons—incomprehensible unless you already knew their

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meanings. She touched a magnifying glass and the map on the navcomp screen zoomed in. Experimentation proved it to be a three-step toggle: close-up, normal, and wide angle.

"Check for traffic behind, signal, then shift to the right-hand lane," the computer advised. "Prepare to exit in half a mile."

Sulbertson laughed. "They always put those little warnings in there. 'Check for traffic . . .' 'Make a *legal* U-turn . . .' I really hope nobody out there driving is dimbulb enough to need them. But . . . 'Here there be lawyers,' like it says on the old maps. How about that route, Navigator?"

"Um. It looks like it bends east for a while, then goes north toward Edwards and intersects with . . . , uh, Fifty-Eight."

"Yeah, that's what I thought." Sulbertson drifted across the highway and off the exit onto the new road. "Not an Interstate, but not a bad road, either."

It was wrong to tempt the Fates with words. The Fourteen would have been a very good road indeed, Jacinta thought, had it not been for the several tons of mud that had broken loose and flowed across it. Hills rose on either side of the road. Now one rose directly in front, too. Red tail lights were jumbled all together where the cars had stopped or pulled aside. It was single digits in the morning, but a fair number of cars had halted in front of the mud. Sulbertson stopped the Wraith and they stared at the obstacle. Lightning flashed above them. Rain drummed on the roof of the car and blew in sheets across the road. The wipers rocked hypnotically and the navcomp displayed now-useless messages on the heads-up. Jacinta felt a small flower of despair blossom within her. She would never make it to the academy now.

"Must have just happened," Sulbertson said.

"How do you know?" Her voice came out dull and flat. Not one of the canonical Voices, at all.

"No bulletin download yet on the traffic—" Even before he could finish, the on-board announced that the highway had been closed and promised to recalculate another route. Sulbertson pointed a finger at it. "*Now* you tell us. Better shut it down," he added. "There *isn't* any other route. Poor thing'll go crazy trying to compute the incomputable. It'll try to take us all the way around to Barstow; and there's no guarantee that the San Bernardinos are any better." He looked at the mudslide again. "Jeez, I hope nobody was under that when it went."

Jacinta pressed the red toggle and the map screen blinked and faded. The car's cab darkened. She hadn't realized how much the navcomp screen had lighted the interior. "Now what?"

Sulbertson scowled and drummed on the steering wheel with his two forefingers. "This mess won't be cleared up for a couple days," he decided. "Interstate Five will probably be open in an hour or two. What say we turn back to the Golden State and wait. Catch a little shut-eye, maybe."

"Do you mean in a motel?" she asked in the Voice of Caution.

Sulbertson made an exasperated sound in his throat. "No, you can sleep in the damn car, if that's what you want." He swiped the magcard through the reader and looked into the Facemaker so the car's on-board knew he was the legal renter. The engine restarted, and he backed up and cut across the median to the southbound lanes. The ground was soft and the wheels dug in, sliding a little in the mud before he managed to coax the car back onto the pavement. "What's with you, anyway?" he asked when they had started back down the highway. "It's not like I'm trying to get into your pants, you know."

"That's not for you to decide."

"Looks like I can't win for losing. But do you mind telling me who stacked your particular deck?"

"Is there something wrong with chastity?"

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"What? Hell, no. I approve of it, mostly."

"Well," said Jacinta, folding her arms and looking straight ahead, "I approve of it wholly."

Sulbertson took his hands off the wheel long enough to make a shrug. "How did we get started on this? Look, if you don't Do the Deed, that's no skin off my nose. I never asked, and you're not my type, anyway."

The hiss of the tires on the rain-slick pavement was the only break in the silence. Jacinta closed her eyes and recited the Fourteen Precepts to herself, one after the other. She reviewed the Sixteen Archetypes and pushed the image of Alonzo Sulbertson firmly back into his proper box. Finally, Jacinta broke the silence. "It's not the same," she said.

"Huh? What's not the same as what?"

"'Chastity' isn't 'celibacy'."

"Well. That's good news for someone, I'm sure."

"Good news for *me*." She twisted sideways in her seat to face him and turned her scarf to show the pin. "I'm a silver apple. Do you understand what that means?"

He frowned and spared her a glance. "That's one of those new sisterhoods, isn't it?"

"It means we have each other. It means we don't have to go on being the cannon fodder for your 'sexual revolution'—"

"Hey, it wasn't *my* revolution."

"—or being the playgrounds for 'recreational' sex. Do you know what it is to be sweet-talked, used, and then dumped into single-parent households, like my mother? Do you know how *smug* boys can be when they know they can walk away and a jaded society will only shrug? Well, the silver apples expect better. They taught me confidence and self-reliance and let me know I wasn't alone in my choices."

Sulbertson heaved a sigh. "All I said was—" Raising fingers to tally his points ..."—1) it's late; 2) both direct routes are blocked; 3) the Golden State will clear long before the Sierra Highway; 4) we'll have to wait a couple hours, regardless; and 5) we might as well get some shuteye while we do. If you have a better plan, I'd be glad to hear it."

Jacinta deflated and sank in her seat, hugging herself. Three thousand miles and most of a day of travel piled on her like sandbags. She wished she could close her eyes and wake up at the Academy. That was the seduction. It was so much *easier* to depend on others. If you took no responsibility, you would accept no blame. And, while a blameless life was something to aspire to, there was a wide gulf between *deserving* none and *accepting* none. "I'm sorry I blorked at you," she said. "I'm usually not so fused, but it's ..."

"Yeah, we're all tired. Long day."

"If I'd been listening to the announcements, we'd've made the plane and be snug in the dorms by now."

"It can happen to anyone."

"Why *did* you stay behind?"

"Here's the cloverleaf coming up," he said. "Jeez, it looks so delicate. I heard it collapsed one time in a quake and some cop went right over the edge on his cycle. Keep an eye out for a place to stop." He peered up through the windshield. "I think the rain may be letting—" A strobe flash of lightning proved him a liar, and Jacinta laughed at the look on his face. "OK," he said after the thunder had died, "so I'm no weatherman." Then, as if the shared laughter had been a signal, he said, "You asked why I stayed? Because we don't leave our own behind. I was senior cadet present; so it was my responsibility."

"An officer, as well as a gentleman." The Voice of Light Humor.

The look he gave her was unreadable, not one she recognized from her training. "I like to think so."

Shortly, they reached the butt-end of the traffic blocked by the accident. The Highway Patrol had set up flares and cops in yellow slickers were waving

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people to the shoulder or guiding them through an Authorized Vehicles Only U-turn through the median. "That must drive their on-boards crazy," Sulbertson said with a chuckle. He rolled his window down a crack and called to one of the officers. Another hour or two, the trooper told him when he asked how long the wait would be.

"Pretty bad?" Sulbertson asked.

The cop stepped up close to the rental car as an ambulance rolled up the lane they had cleared for emergency vehicles. "Yeah. Pretty bad."

"I'm trained in EMT work," Sulbertson offered. "Second class license."

"Nah, Squad's on the job. We got all the help we need, dude; but thanks for the offer."

The rain was spraying into the car through the window crack. Another flash of lightning turned everything black-and-white for an instant. It threw shadows. The crack followed so closely that Jacinta was sure it had struck somewhere close by. It was as if God was hunting for her.

"What caused it?" Sulberston asked the patrolman. "The download said slick roads and fog."

"Half right. A commuter plane went down in the pass. Fog kept cars from seeing it until they plowed right into it. Look, I've got three miles of wrecked cars to—"

"A commuter flight?" Jacinta leaned across Sulbertson with a sudden, unreal sense of urgency. "What flight was that? What flight?"

The cop looked startled by her intensity. "I forget the flight number," he said. "It was flying LA to Bakersfield, but turned back when the storm re-formed. Way I heard, wind shear caught it and pushed it down into the highway."

Sulbertson rolled the window down farther and the wind blew the rain into the car. "We rented this car because we missed that flight. Some friends were on board. Were there any survivors?"

"Not that I heard. You had friends on board? Man, that's phat nasty. You were damn lucky to miss the flight."

"Yeah," said Sulbertson, slumping in his seat with a stunned look on his face. "Damned lucky." The rain, spraying on his face, looked like tears.

Friends? Jacinta thought. No, she had barely met them. Holzstreicher, she felt sure she would never have liked. Not merely a man, but a *male*, with all the macho B/S that implied. And Molnar was too stand-offish, a Euro-snob. And Kitmann . . . The Doves Within the Sun were a religious sisterhood. The two of them would have clashed sooner or later. Even Soren, she felt sure—his jokes would have tested her patience in the end.

So she was fortunate not to have formed a bond with any of them. They were strangers, for whom she might feel pity; nothing more. But then, unreasonably, she laid her head into her hands and wept. Not because she had known them and had taken them into her heart; but because she hadn't, and she hadn't.

II. Fortitude

The late summer sun peeled the heat off the desert in shimmering waves, causing the distant Sierra Nevada to waver and dance. Illusive pools of black water glistened on the hardpan flats. Dust devils capered among the cactus and yucca, but the wind that stirred them brought no relief to the sweating cadets.

Sometimes, lying exhausted on her bunk at the end of the day, drained of all energy, Jacinta Rosario wondered if she had chosen the right life for herself. It was not the physical regimen (though that was hard and uncompromising) nor was it the vagaries of the differential calculus (beside which obstacle courses and scaling towers faded to insignificance). No, it was the looks she saw in others' eyes or the words behind her back that she was never quite quick enough to catch. As if she did not belong there. As if she ought to be dead.

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Chance ruled the universe, and chance, on a whim, might have easily sent her plunging to a fiery death with Soren and the others in the commuter plane, placing her *under* the desert rather than *on* it. That was a thought she shared with no one, not even with cadet captain Alonzo Sulbertson, in whose sometimes-haunted gaze she thought she caught reflections of her own bewilderment. He seemed to have shut down his memory of that awful night on the Grapevine.

Yet at night, when an impossible canvas of stars was spread above her, or when the training clippers lifted with their crews of upperclassmen, or when beautiful and exotic airframes soared overhead from the test fields at nearby Edwards, chance or no, she knew no other life was possible than to spread her wings as far as she could, and soar. Fortitude. She would see it through, ghosts or no. Ad astra per aspera.

I left my momma far behind
To march through dust; but I don't mind!

They drilled. In rank and file across the hardpan flats, twisting and turning to barely intelligible commands, feet striking the soil in crude approximation of simultaneity, kicking up a bitter, alkali cloud. It coated Jacinta's hair and face and forced its way into her nose and throat until she thought she could no longer breathe.

"This is absolute air," cadet Ludwig Schimmelpfennig had complained one time while he marched beside her under the blistering desert sun.

"Iyho," Jacinta told him. *In your humble opinion.* Though she had to admit that when it came to close order drill in the high desert he had a point. She hadn't expected so much mouse at the Academy. But bits and pieces of military training, like the fossilized relics of extinct species, kept popping up in what was supposed to be a no-foolin' Twenty-First Century curriculum.

"Imgdo," Schimmelpfennig retorted. "This is how phalangists trained in ancient Greece, for crying out loud. What's marching got to do with astrogation or flying clippers?"

Jacinta didn't answer him. He was talking for himself, anyway. The other cadets called him "Lou Penny," but privately, Jacinta had labelled him The Bitchmeister. There was no aspect of Glenn Academy with which he could not find fault; and the Academy (indeed, the entire world) would be so much better run, if only the Powers That Be would accede to his wisdom.

The cadet drill sergeant ordered a countermarch for no particular reason that Jacinta could see, except maybe whimsy, and the first-year cadets went through the evolution with a bit more polish than they had shown at the semester's start. The first rank turned smartly about and the files twisted back on themselves. Yungduk Morrisey, Jacinta's corporal, smiled at her as he passed to the rear. Jacinta acknowledged his attention without returning it. If Morrisey had the yen to jolly with her, he'd have to do it in his dreams.

I don't know, but I've been told
Outer space is mighty cold!

They climbed and dodged. Through obstacles, across rope bridges, up walls. There was not an object in Known Space that they did not have to go over, go around, or go through. Jacinta learned what a cactus felt like. She learned how cold the desert grew at night. She learned how to wriggle through conduits that would give a snake serious pause. She learned how far down the ground could be.

"Climb, Rosario!" ensign-instructor Debra Matusek bellowed from the ground. "No sight-seeing up there!"

Jacinta wrapped her right arm and leg around the climbing rope and hung for a moment to catch her breath. She would be sore tomorrow, no doubt about it. Maybe a little less sore than in April, only five months ago; but sore

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enough. At the base of the climbing tower, Ms. Matusek was a small person, indeed; though her voice was certainly loud enough. Jacinta held her left hand out so her thumb covered the ensign.

"I could squash you like a bug," she whispered and chortled wickedly.

Now how could anyone climb a rope that quickly? Matusek was beside her on the wall, gripping the next line over. "I couldn't hear that, kay-det," she said.

The instructor was not even breathing hard. Jacinta muttered something under her breath.

"What was that, kay-det? Are my ears going bad?"

"I said, 'this is mouse'." Jacinta stuck her chin out, daring refutation. "So I climb slow. I'm climbing against gravity. There's no gravity in space."

Matusek's eyes widened. "You don't say? Why, I'll be . . . Hey, Jorge!" she called to the other instructor. "Kay-det says there's no gravity in space!" Jorge Izquierdo slapped his forehead with the flat of his hand. Matusek turned to Jacinta and smiled sweetly. "Three gigs, kay-det. Permanent, until you can tell me why what you just said was too stupid for words." Matusek rappelled to the ground. "Up and over, Rosario! Rest period's over!"

Break my body, burn my brain!
I sneer at problems, laugh at pain!

They studied. When they weren't slamming their bodies, they were banging their brains. There weren't many lectures. Nineteenth century mass production methods? No, the modern era meant customized, one-off manufacture. A few lectures to put everyone on the same wavelength; occasional discussion groups; some one-on-ones with the instructor. But mostly structured modules over the campus intranet: sims and scenarios; problem sets; reference materials; chat rooms; frustrating conversations with Artificial Stupids. The whole thing was set up like a computer game. You could work at your own pace, identifying problems and solving them, advancing from level to level; but, like climbing that forsaken tower, your pace better not be too slow.

At first, like most of the others, Jacinta worked from the terminal in her room. She was used to doing for herself, and the silver apples emphasized self-reliance. Yet, early on, she stuck dead on a case study in engine burn calculations. She jiggled and juggled newtons and kilos until she dreamed in mass fractions. The rocket in the sim mocked her, sitting silent on its virtual pad. She could not bring herself to launch it because she had no confidence in her answer. There was not enough information in the case study. Lou Penny figured they wanted you to take your best shot. "Real world, you *don't* always have all the skin before you gotta act," he said and confidently launched his virtual rocket on his best guesstimate.

It was a beautiful sight, narrowcast over the bunny class intranet. Jacinta watched it climb and climb and . . . run out of fuel and turn and crash in a fireball no less spectacular for being virtched. In the common room later that day, Lou had bitched that the question hadn't been fair and Jacinta had sighed and said if she only knew what the forsaken *fuel* was she could look up its specific impulse in the deeby; and Kenn Rowley said no-brainer, it was Aerozine 50 with a Nitro Tet oxidizer—I_{sp} was three hundred twenty seconds—and the *real* problem was the unknown fuel mass; and Yungduk Morrisey went whaddaya mean "unknown" and rattled off the figures—and at that point they all stopped talking and stared at each other.

Not all the problems were like that; but ever since, Jacinta and the others had worked together in the common room. You never knew who might have the one crucial piece of information to solve the problem. And it could be that not all problems had to do with launching ships.

When I'm dead, don't bury me!

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I'll float in space eternally!

They kept house. Though not very well, according to upperclass inspectors. Cadet captain Sulbertson could explain in great detail every shortcoming of her room, from uniform coveralls out of place in the closet to assignment logbooks not retrieved on a moment's notice. This, at least, Jacinta tolerated. You didn't want clutter in a cramped orbital ship.

"You mean you can't find it, cadet?" Sulbertson leaned forward, invading her space—in her face enough that they could have traded faces. He wore white cotton gloves with a damning black smudge on the forefinger. Jacinta suspected the gloves were made that way, with the smudge printed in place.

"No, captain. I mean, Yes, captain! I mean, I can find it if you give me a minute." The logbook was on her desk. She'd been working Principles of Rocketry shortly before the surprise inspection. It was underneath those papers. She was sure. Dimly, Jacinta could hear the sounds of scrambling cadets down the hallway in the dorm. *It's not fair*, she told herself. *He always stops here first and that gives the others time to get ready.* Sometimes she thought Sulbertson took special joy in harrassing her.

She realized she was feeling sorry for herself. *The sorriest thing in the world*, Mother Smythe used to call that. Self-pity is self-defeating. Jacinta squared her shoulders. "Start counting, captain," she said in the Voice of Confidence.

Sulbertson cocked his head. His big, white eyes regarded her and he pursed his lips. "All right. Go! Gig, mark one . . . Gig, mark two . . . "

Jacinta broke for the desk, threw the papers aside, and—Bone! There was the logbook!—she seized it, whirled and thrust it into Sulbertson's hands just as he reached "Gig, mark three." Sulbertson noted the problem most recently worked, keyed in his inspection stamp, and handed it back to her. "Good enough, Rosario. Delete two gigs for daring the challenge. Add one gig for messy floor." He indicated the papers she had scattered in grabbing the log.

"Yes, captain," she said. "Thank you, captain."

When Sulbertson inspected the dorms, he never let on, by word or gesture, that he and Jacinta had ever shared an evening of tears. Punctilious and precise, he went by the book, checking and inspecting and—invariably—rubbing his white glove across the one surface she hadn't dusted. Even when, as sometimes happened, he spared her a backward glance on leaving, his eyes were never those that had wept for an hour on her shoulder, mixing his tears with hers over friends they had never had.

The whole thing was clearly designed to drive off as many bunnies as possible. Send them hopping back to mommy—those who had one—before spending troy on the real training on-orbit, mano-a-mano under an experienced captain-instructor. Snap inspections, arbitrary penalties, impossible assignments, petty harrassment. Foo a test, a courtesy, leave the least little thing out of place in your room, and you got gigged. Rack the gigs and you couldn't leave the campus to sample the sizzling night life of Tehachapi. The meek might indeed one day inherit the Earth, but Outer Space was evidently reserved for the anal-retentive.

September rolled around and the fall term nooboos began to trickle in by ones and twos. Jacinta was assigned along with a few other underclassmen to escort the new arrivals to their dormitories. "Here's your list, cadet," Ensign Dubois told her, handing her a thinpad and stylus. She pronounced her name "Duh Boyz" and had no doubt heard all the usual jokes. "Names and billets. They sign here . . . " Pointing to a box on the electronic form. " . . . and here. You check them off there, and there. These . . . ," a hardcopy flimsy, ". . . are your talking

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points. You don't have to memorize them, but tell them the gist of it. Your thumbprint goes here when the list is complete. That downloads to the CPU."

Jacinta scanned the sheet. Welcome aboard. Here's your room. There's the head. That's the showers. Class orientation is scheduled for . . . Yadda-yadda-yadda. "No problemo, ma'am. Not exactly rocket science." She saluted.

You were supposed to salute—more military mouse. Salute anything with rank on its cuffs, including ensigns themselves only a few years released into the wild. (Though it did sound strange to call a woman in her mid-twenties "ma'am.") Ensign Liz Dubois grinned at the "rocket science" comment. She was an assistant professor and taught orbital mechanics.

Danger, danger. Whom the gods notice . . . Jacinta began edging toward the door.

"Speaking of rocket science. . . ." Dubois said, stopping Jacinta just before she could make her escape. "Are you having any problems with the new module?"

"None I can't handle, ma'am." Using the Posture and Voice of Confidence.

"Hmm. Don't forget, I monitor your log. You haven't mastered the second problem set yet."

"I will." Did the confidence quaver just a bit there? She refused to let it quaver.

Dubois shook her head. "Needs more'n grit and determination, gal." A faint echo of Texas twanged in the professor's voice. She stabbed a finger at Jacinta. "A satellite's perigee," she said suddenly, "is three hundred klicks above mean sea level. Its apogee is thirteen hundred klicks. That's a pretty damn eccentric orbit, isn't it, cadet?"

Jacinta grimaced. One of Dubois's more charming habits was that of springing snap questions at you. Any time; any place. You didn't have to be in class to be on the spot. In fact, you didn't even have to be *taking* her class. Jacinta had seen upperclassmen stopped and quizzed by the wiry, young blonde, and she suspected that visitors and even other professors were likewise put on the grill from time to time.

But . . . an apogee four times higher than perigee? That *was* some kind of eccentricity. Except that Dubois never asked anything so straightforward. There was always a hook. A question's no good, she had announced once while overriding a Schimmelpfennig complaint, unless it *is* a trick question.

"Um, it certainly *sounds* eccentric. . . ." Jacinta carefully studied the other woman's face and posture, looking for a clue that the comment was warm or cold; but Dubois had the most difficult body language she had ever encountered. Like trying to scread a blank monitor. "But . . ." Jacinta closed her eyes and pictured the orbit. An ellipse, one focus at Earth's center. Shy turn grazing the Earth; far turn way out there . . . . Oh! "But eccentricity is measured from the focus of the ellipse, not from mean sea level, and the focus is at the center of the Earth. When you add in the Earth's radius—"

Dubois nodded, smiling so you'd think she had answered the question herself. "That's enough, Rosario. It's understanding that matters. You can teach a *machine* to do the arithmetic."

That was bone with Jacinta. She had forgotten the Earth's radius, anyway.

There were a half dozen others waiting in the admin building when she got there. Yungduk, as usual, thought he was in charge, and tried to get them lined up like they were in review. Jacinta and the other guides ignored him.

"He wants us to line up like ducklings," Lou Penny whispered to Jacinta. "Get it? Young duck? Ducklings?"

Jacinta ignored him, too.

"Yungduk's a whack name, anyhow," Lou said. "Look at all the whack names here . . . " His thumb worked the scroll button on his own pad. "Kyle . . . . Joachim . . . . Masterson . . . . What kind of first name is Masterson?" Jacinta

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slouched in her seat and stretched her legs out. The first plane into Tehachapi landed at nine, and it would take a while for the van to cart over any cadet-applicants. Some might show at any time—those who drove themselves cross-country—but Jacinta figured she had a half hour to burn before she would shepherd any nooboos.

When the cadet colonel entered reception, Yungduk jumped up and saluted. So did some of the others. You didn't have to leap to attention—Glenn was not a military academy, exactly—but you did have to show respect, so Jacinta sat up straighter and gave the woman a polite salute. Lou kept his nose to his thinpad and pretended not to notice. The colonel looked them over, appraising them, before giving an as-you-were.

There was a test in all of this, Jacinta was sure; though what it was, she didn't know. The Academy's unofficial motto was: You're Never Not In Class. So everything you said and did went into your assessment. Lou and some others grumbled about Big Brother, but Jacinta was used to it from her years in the silver apple retreat.

Cadet Colonel Noëlle Nieves, at twenty-two, was about as far from Big Brother as you could get. Little Sister, maybe. Short and solid, but fine-featured, with a dusky complexion, high cheekbones, and cloud of brown, curly hair that told of family roots on three continents. Her eyes, set in a long, square face with a strong jaw, were by turns severe, laughing and mischievous. It was said, after Lights Out, that the colonel's bunny days were legend among the staff instructors; but whatever stunts she had pulled were a closely-guarded secret.

"Here's another one," Lou said. "Bucktail. Bucktail Smith...."

Jacinta fought the impulse to ask him what he thought of "Jacinta Rosario." What right did a "Ludwig Schimmelpfennig" have to laugh at someone else's name?

"Which one of you cadets," asked Colonel Nieves, "has Ursula Kitmann on your list?"

The others scrolled their thinpads while Jacinta sat numb in silence. *Ursula Kitmann?* A face rose before her: a young woman with long, blonde hair and violet eyes; but a face grown sketchy and indistinct. *Ursula Kitmann?* Echos of hurt long buried beneath brash cheer. She hadn't known anyone had survived the crash. She hadn't even checked.

"I do," said Kenn Rowley.

"She's booked on the nine o'clock flight," said colonel Nieves. "When she gets here, the superintendent would like to see her right away."

"Yes, ma'am."

"Wait." Jacinta had found a voice, though it wasn't one of the canonical Voices. "Wait." Rowley, Yungduk, the colonel, they were all looking at her. "I'd like to escort applicant Kitmann, ma'am."

"You would," the colonel said, letting a question curl into the words. "You are ...?"

"Cadet Rosario, ma'am."

Colonel Nieves regarded her silently while an inner clock ticked forever in Jacinta's breast. "I see," the colonel said after what must have been only a moment. "All right. Do it." She nodded and left the reception area. The civilian receptionist seemed puzzled at the exchange; but she hadn't been around last March. Jacinta Rosario and Lonzo Sulberston had survived the crash by the simple expedient of missing the plane.

Ursula Kitmann liked to do things the hard way.

Now, here is a mystery. How can one gauge the changes in a person barely met, and known not at all? Start with the coarse physical features. The golden hair was shorter and bore a streak of platinum when the light struck it just so. The jaunty, confident walk had grown a limp. Stitches on cheek and jaw had faded to red scars. But what of the inner

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person? Had the glint in the eye faded, too? Did hesitation echo limp? Had the mind survived the crash half so well as the body?

Jacinta's had not, and she hadn't even been in it.

Two signs there were that she could read. For one, Kitmann wore, not a discrete pin on her collar as before, but a broad scarf around her neck on which a white dove traversed a golden sun. For another, she had flown—and flown the LAX to Bakersfield route. A vagrant breeze lifted her hair as they crossed the quad to her assigned dormitory and Jacinta noticed that something plastic had replaced the woman's right ear. What further, she wondered, might be hidden by the scarf from fascinated eyes?

So. Ursula. How was the plane crash?

How did you open a conversation? Kitmann had recognized her. Jacinta was sure of that: A face that opened up at the introductions before collapsing behind guarded eyes. Jacinta wondered about Soren and the others—but could find no words to broach the subject. Jacinta had experienced mere anguish that night, while Kitmann had been tossed into the vestibule of death. If Jacinta, herself, suffered night-time bouts of self-blame, what must the other sister feel? It was better to leave the topic unspoken. Eventually, names unspoken gave answer to questions unasked.

"What did Superman have to say?" Jacinta asked, seeking a neutral ground on which they might meet again. The superintendent did not ask to see every incoming cadet-applicant, and Kitmann had come out of the office with a countenance even more solemn than she had had going in.

Kitmann tossed her head and, briefly, the prosthetic ear rebuked Jacinta. "That's an awfully flip way to talk about a man like Forrest Calhoun."

Frost in the desert, defying the heat and the sandpaper breeze. The ice in Kitmann's voice froze Jacinta's heart, and she turned away. Then, squaring her shoulders: "Those are the classrooms and infocenter," she told the nooboo using the Voice of Polite Distance and pointing to the rose-colored buildings with Spanish tile roofs on the south side of the quad. "Northside are the dorms. Your billet is in Gagarin Hall—that's the first one on the right."

"Wait." They had come to the monument that dominated the center of the quad. Kitmann held up her hand, then stepped slowly toward it. Jacinta watched her, noted the hobble in the walk, marked the stiffness with which the arm reached out to touch the smooth black iron.

Ad Astra was its name. The base was a curled and bubbled mass of plated aerogel that climbed upward, growing thinner and smokier as it did. Shot through with streaks of red copper near its apex, it seemed to billow like the exhaust plume of a spacecraft in lift phase. It leaned toward the east—the open side of the quad—as ships did during lift. At the very tip, cleverly foreshortened to suggest an even greater height, a bright figure yearned for orbit.

What was the figure? The Accepted Wisdom held it was an SSTO, but no one knew for sure. It wasn't fully visible from the ground. Every year, at least one cadet would get caught trying to climb the plume to find out.

Jacinta waited patiently for her charge to finish gawking. *You won't make it*, she told the awkward figure. The regime was too demanding; they cut you no slack. Kitmann's broken and cobbled body wouldn't take the grueling pace.

When the woman rejoined her there were recalcitrant tears in the corners of her eyes. So the 'boo must know that, too. It was pointless to start what you knew you could never finish. So why had she come back? To upbraid Jacinta with her presence? But Ursula only placed her right hand on Jacinta's arm and said, cryptically, "Only three of us left."

* * *

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Kitmann tried hard, there was no denying that. Over the next few weeks, Jacinta gauged her progress. They were often together in the same training group—with no formal division into classes, everyone moved at her own pace—and while Kitmann did well enough at the theory and the problems and the sims, the physical mouse could prove insurmountable—in the case of the scaling tower, literally so.

"Is there something I need to know about, kay-det?" Ensign Matusek asked one time while Jacinta awaited her turn at the "Wailing Wall." High above, Kitmann dangled under the scorching sun, moving neither up nor down. An arm shifted to a higher grip, and Jacinta could see the muscles bunch as Kitmann strained to lift herself another length.

"She should give up," Jacinta volunteered in the Voice of Concern, "before she hurts herself."

Matusek shrugged. "Seems I watched you one time 'bout in the same situation."

"That was different."

"Could be right, kay-det. Kitmann stopped because she gave out, not because she gave up." She scowled at the Wall. "Morrisey! You and Rosario get up there and help Kitmann down."

Yungduk threw a sketchy salute and dashed off. Jacinta hesitated. "Why me?"

"Because you earned it, Rosario. Bounce!"

She and Morrisey monkeyed the ropes on either side of the 'boo, Jacinta on the left, Morrisey on the right. A part of Jacinta's mind expressed grim satisfaction with how quickly and smoothly she went up. Scaling had become almost contemptuously easy for her. All it took was practice, and Matusek nipping at your heels.

Kitmann was red-faced and huffing, Jacinta saw when she reached her side. Her arms were knotted and they trembled under the strain of holding her weight. She wouldn't look at her rescuers, but kept her gaze fixed on the top of the Wall. "We're supposed to help you down," Morrisey said.

"No, thanks, corporal. I can make it." Kitmann pulled; her feet scraped for purchase on the the thick hemp cable. A harsh grunt escaped her. But she didn't move.

"You're favoring your left arm," Jacinta suggested helpfully. "Twine your legs around the rope. That'll take some of the strain off."

"No flubber, Kitmann," said Morrisey. "Ensign told us to bring you down. You don't want to get Matusek mad at us, do you? Besides, if you do make it to the top, all there is, is you have to rappel down the other side."

"It's important," Jacinta said. "Weightless doesn't mean massless. You gotta develop your upper body strength to shift cargo or work repairs in ziggy. But there's no training deadline. You can pace yourself. Don't force it all at once."

"I know I can make it." The statement emerged through clenched teeth.

"Sure you can," said Morrisey, "but not today."

Maybe not ever, Jacinta thought.

Kitmann looked from one to the other. Then she began to lower herself without waiting for their support. But again she tried to avoid putting all her weight on her left arm, so that she slipped and slid down the rope a few feet. She sucked in her breath.

Morrisey said, "Shit," and skinnied down the rope to catch up. Jacinta followed.

"I think I have a rope burn," Kitmann said when they reached her.

"Look," said Morrisey. "We'll help take some of the weight off. Rosario, hang onto her. I'll go up top and get a line. Kitmann, put your arms on her shoulder."

"I won't let go of the rope."

"One arm. You're used up. That's why the ensign sent us. It's not like you're the first cadet to need a carry-down. An otter has to learn to rely on her mates."

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"Without depending on them," Jacinta added reflexively in the Voice of Independence. Both Kitmann and Morrisey looked at her; then Kitmann nodded and, with marked hesitation, put her left arm around Jacinta's shoulders.

Jacinta almost lost her own grip on the rope. The arm wasn't real. It felt fuzzy where it touched the bare skin of her neck. And it was the wrong temperature. . . . Jancinta shot Kitmann a moment's horrified glance, saw silent defiance, and made no comment while they waited for Morrisey.

After they worked their way to the bottom and unclipped the safety lines, Kitmann dropped to the sand. Ensign Izquierdos brought the first aid kit and checked the rope burn on her right arm. *The natural arm,* thought Jacinta. She couldn't keep her eyes off the prosthetic. You couldn't tell by looking at it. And it moved and flexed like the real thing. *Something new.* It even had, as she noticed when she squatted next to Kitmann, tiny hairs and goosebumps. She couldn't see where it attached. Near the shoulder, under the sleeves of the blouse; or was the seam itself artfully hidden among the other scars that zorro'ed Kitmann's body?

Matusek clapped her hands rhythmically. "All right, you gawkers. Next rank, up against the wall!"

That was Jacinta's rank. She squeezed Kitmann's arm—the "wrong" arm—but the other woman turned her head as if she had felt the pressure. "I'll find you later," Jacinta said. "We need to talk."

The violet eyes gave no answer. Jacinta did not take that as a No.

Evenings were their own and everyone sought release in different ways. Some just sacked in their rooms; others gathered in the common room for talk. Computer games were popular—especially flight sims of various sorts—and so was surfing and trolling in general. Scratch teams on the athletic field played whatever sport was seasonal. A few cadets played instruments, and both a bounce band and a wind quintet were active. Jacinta found Kitmann on her knees in the chapel.

OK, Jacinta thought as she watched from the back of the room, everyone was entitled to her own notion of a good time. *But you'd never catch* me *kneeling.* As the Eighth Precept held, *You are taller on your feet than on your knees.* Jacinta had no use for self-abasement. Groveling got you nothing but dirt in your face.

It wasn't really a chapel; it was a medium-sized room in the recreation building that was done up in soft colors and woods and a variety of leafy plants. It was a room where you could be alone with yourself, if that was what you wanted, or you could participate in scheduled communal services, real or teeped. Pixwalls and threedy tanks could run various scenarios, so the room could emulate church, meeting house, mosque, synagogue, or temple as the spirit moved. There was even a subroutine that reproduced the auditorium of the Society for Ethical Humanism in Manhattan, complete with its niche statues and stained glass windows of great philosophers. It looked, Jacinta had thought when Kenn Rowley showed it to her, more like a church than some churches.

Kitmann had called up a Catholic setting; not surprising, since the doves within the sun were affiliated with an order of nuns. Jacinta didn't know who had come up with the idea of "signing up for a term" rather than making a lifetime commitment. Perhaps the religious orders had been inspired by the secular sodalities that had sprung up in the cities; or perhaps the whole movement had started in convents and mother houses hungry for postulants and seeped from there into the secular world. No one seemed to know. One day there were women's shelters and support groups and hot lines; the next, there were the sisterhoods, precipitating

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like crystals from a supersaturated solution. And, of course, convents had been the original "women's shelters."

Jacinta watched from the back of the room. Kitmann had chosen an interactive program. She knelt on a padded prie-dieu beside a threedy holoscreen and spoke in a low voice to the robed deaconess that flickered in the tank.

Granted, a well-trained neural net could emulate a conversation with astonishing fidelity (and was considerably cheaper than a shrink); but it was only a simulation. Outside the boundaries of its knowledge base, the net would flounder with random replies—which was why pilots seldom discussed philosophy with their onboard navcomps. In the end, you were only talking with yourself.

Of course, a lot of people were the same way. Outside their areas of expertise, their conversation consisted of canned opinions and random statements ....

Eerily, the hologram turned in her direction. "Hello," it said in a pleasant contralto. "Have you come to join us?"

It's only reacting to the infrared sensors. Input reads a second IR source at 98.6°F. Deeby says that's human bodtemp. Triangulation gives location. RAM access to the greeting file pulls up a standard I/O statement. That program did not *actually greet me.*

But it needed I/O to function—just like people. "No," Jacinta said, "I was looking for Ursula."

Kitmann rose from her knees. "We'll talk later, Priscilla."

"Are you sure?"

"We'll talk later, Priscilla."

"System shutdown confirmed." The dancing lasers blinked out and the "Christmas tree" inside the threedy tank slowed to a stop. The holoscreen placard read: SYSTEM STANDBY MODE.

Jacinta pointed to the screen. "You think they'll ever ordain one of those?"

"It's only a program," said Kitmann. "A construct based on the original Priscilla from *Acts*. Sometimes I talk with Chloe or Phoebe or other early deaconesses, or even with the women-apostles, like Magdalen, Salome, or the Marys."

"Just making a joke." *And you don't have to get snooty.* "I was looking for you."

Kitmann folded her arms. "You must have been looking hard to find me here."

"I— How's the rope burn?"

Kitmann displayed the angry, red welt on her arm, almost like a trophy. "The protein gel enhances skin cell growth. In a week, it'll be as good as new. I've been burned a lot worse." Her defiant gaze faltered. "A *lot* worse."

Jacinta flinched at the answer. If she and Sulbertson hadn't missed the plane that day ... "Look, up on the tower, I couldn't help notice ..."

"My new arm?" Kitmann held the *faux* limb up, turned it, flexed the fingers. "Hot spit, isn't it?" She was wearing a short sleeve blouse and Jacinta could see arm muscles move under the skin. Yet, they weren't muscles and it wasn't skin. "Wish I had another just like it."

Jacinta gave the self-mocking smirk on the other's face a fearful glance. "You can't mean that!"

"Why not? It's tougher than the real thing. 'If you cut me, I do not bleed.' The 'muscle tissue' is MEMS technology—micro-electro-mechanical systems. An Artificial Stupid neural net in the titanium 'bone' runs the electronics that extend and contract the MEMS. And an interface just like the ones that cheeseheads use runs the Stupid—except the interface is implanted in my arm instead of a skullcap."

"There was a girl at my school who had an interface put in her arm, except she doesn't have the prosthetic. That was four years ago. She was a senior and I was a freshman."

"Four years ago, they didn't have Bionic Arm," Kitmann told her. "Four *months* ago, they barely had it. Me, I'm an official, government-sanctioned guinea pig, in person."

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"Experimental . . . . What if it doesn't work?"

Kitmann leaned toward her. "Then how will I be worse off?" she asked in flat, measured tones. Then she laughed and straightened up. "I thought about getting a hook. You know, like that cartoon pirate? That way, I could gaff any boys that got too jolly. Or go fishing . . . ." She held her arm out. "Go ahead, feel it."

Jacinta hesitated a moment; then ran her hand along the 'skin' of the bare forearm. It felt soft and fuzzy, like velvet. But it was cold, not human. Ambient temperature, like a lizard. Kitmann shivered at the touch.

"That tickles. I think. There are sensors in the 'skin,' you know. More MEMS. Pressure, temperature. They had to train me to feel those; just like I trained the neural net. I would think about a hand or arm motion and the interface would pick up the neural signals and translate it to electronics. Then the Stupid would try this or that motion and the tutor program would encourage it until it got it right. That was weird; but it was weirder the other way. They'd apply a heat source, or a pin, or an ice cube or something, and I would get . . . feelings." A momentary disquiet passed across her face. "I can't describe them. It would be like describing the smell of A-flat, or the sound of purple. But I would go, 'Oh, a pin. That must be pain.' Or, 'An ice cube. That must be cold.' After a while, my brain would recognize the inputs automatically; but it's not . . . an *immediate* sensation. It's more like the way a tone-deaf woman hears a Beethoven symphony. Recognition; but it doesn't hit the gut. Hey, you want to see something? I can make all the MEMS stand up." Kitmann held her arm straight up at the elbow and concentrated. Then, like a dog's hair bristling, the forearm became . . . fuzzy. It looked like a bottle swab. Kitmann laughed. "You should see the look on your face."

Jacinta shook her head. "You should see the look on yours." She shivered. "It's creepy." The arm or the look? Jacinta didn't know.

Kitmann thought she meant the arm. "It looks a lot less creepy from my side. I guess you'd be happier if I was wearing a wood carving; or maybe part of a department store mannequin. Or better yet, I could just wave a stump around. Then you could feel sorry for the poor cripple. Hey, this flubber isn't so bad. It looks and acts like the real thing. Better, some ways. I can crush soda cans with my hand. . . ."

"That's no big deal."

"Full?" Kitman grabbed Jacinta by the wrist and squeezed. Jacinta winced and tried to pull away. Kitmann's hand was a band of velvet iron. "Feel that? The bionic woman, that's me." Kitmann released the arm.

Jacinta rubbed her wrist. "That hurt."

The violet eyes were unreadable. "You don't know what hurt is."

A long silence followed, which Jacinta broke when she said, "Look, I'm sorry I missed the plane."

"That's not what hurt. What did you want to see me about?"

"You're afraid to put too much stress on that arm, aren't you?"

Kitmann rubbed her arm just below the elbow. "Longitudinal stress hurts at the joint. I'll get used to it."

"You could hurt yourself."

"And your point is . . . ?"

Jacinta took a deep breath. There was no easing up to it. "You won't make it." Kitmann pulled back. In the dead silence that followed, the two locked gazes. Jacinta was the first to look down. "No matter how hard you try and no matter how much pain you put up with, you won't make it."

Kitmann shook her head. "I won't give up."

"You should. For your own sake," Jacinta said, using the Voice of Concern.

But Kitmann was not attuned to the nuances of tonalities. "You don't want me here. That's the heart of it. *You* don't want me here because I—"

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"That's not it—"

"But, hey! I'm used to not being wanted. My bio-mother and bio-father used to trade me off like a chunk of hot plutonium after they fissioned the family. Until the doves took me in, I never lived anywhere longer than nine months."

"Kitmann . . . !"

"The name's Ursula, but you have to pick it up and use it. Excuse me, I've got a life waiting." Kitmann shoved—with her left arm—and Jacinta staggered back into one of the benches that served as pews. She recovered her balance and started after the other woman. She had to explain, make Kitmann understand. That she *didn't* have a life waiting; at least, not here. But the dove turned at the door and pointed a finger at her.

"Don't chase after me," she said. The violet eyes were wet, her cheeks flushed. "Stay here." She looked away. "I thought there were three of us left; but I guess I was wrong."

Afterward, Jacinta tracked cadet captain Sulbertson to the simulator room and asked him if there were some way to help Kitmann see reason—to change her orbit before inevitable failure killed her spirit. But Sulbertson only leaned back in the simulator's command chair and rubbed his chin.

"How many times you go down 'n see her when she was in rehab?"

"Captain, I didn't know that anyone survived the crash."

"Did you ask her about the others?"

"I—" Jacinta looked away. "I couldn't. I tried, but . . ."

And Sulbertson shrugged, as if, somehow, questions had been answered.

They found Kitmann the next morning, unconscious, at the base of the scaling tower. She had gone out in the night to try again, alone, and at some point had lost her grip and fallen to the ground, suffering a concussion and a re-broken collar bone. The Aid Squad was on it, and the cadets in the morning training class encircled the unconscious body, whispering among themselves. It was Bucktail Smith who pointed out that she had fallen on the far side of the tower. It was one of those things that everyone had seen, but no one had noticed. Until Smith spoke up, the implication had not sunk in. Kitmann had made it over the top.

Which made it a shame that she was to be expelled.

"Cowboy" Calhoun was a legend in his own time. He knew it and he gloried in it. Others could take the aw-shucks-it-was-nothing route. It *wasn't* nothing. He had done some pretty damn important somethings, and the mementos in his office at Glenn Academy were intended to remind visitors of that. Test pilot on high performance airframes. Early flight tests on SSTO's, when no one was entirely sure they could lift enough fuel to come back down. Pilot on the Skopje Rescue. "The Farthest Man from Earth" during the long, lonely FarTrip expedition—where, with Ignacio Mendes and Iron Mike Krasnarov, he had discovered the first hints of the Visitors. He even had photographs from his stint at the first, *ad hoc* spaceflight academy, the one at Ames Field, where he had trained Chase Coughlin and others.

So, yeah, he was a legend in his own time, but his time had passed, and he knew that, too. Now he was Superintendent of Glenn Academy—ensuring that the next generation of ballistic and orbital pilots would not be a bunch of freaking cowboys like he had been. Age had whitened his hair in places, though perhaps not so much the quantity of years as what had been packed within them. He still flew, but he no longer flew on the knife edge. Orbital transfers and dockings; but not max-Q; not the rotation maneuver or the Swoop of Death; not the new frames or the new fuels or the new materials, where no one knew where the edges were until men and women the likes of Calhoun-that-was

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pushed the envelope out over those edges and pulled it back before it fooed, and where the smallest misstep might end in a blackened hole in the talc of the high desert.

Jacinta hesitated on entering his office and scoured her mind for a recitative to call on her inner strength, and ... there wasn't one to deal with this. *Stand proud in the face of authority. Do not quail* .... Yet, it was not fear she had to overcome, but awe—and something akin to love. Calhoun was a man, and black; but Jacinta wanted to *be* him in all the ways that mattered.

Calhoun's desk was cluttered, but organized, the habits of a man who might need to find something fast in an emergency. The icons on his virtual desk were equally well-arranged. He looked up from a paper he had been reading.

"C'mon in, gal. I don't bite." There was a trace of East Texas in his voice, something that lingered far in the back of his throat. A black-and-white photograph on his desk showed a bearded man in dungarees and a battered, broad-brimmed hat, grinning beside a large cotton bale. *First Bale, 1976*, the inscription read. Two white men and three blacks knelt in front, also grinning at the camera. Their hands were thorn-scratched and black with dirt. A young boy, perhaps twelve, stood beside the bearded man with a face full of impossible pride. Glancing at Calhoun, Jacinta could see the older man looking back through his eyes of the son.

"You have his face," she said.

Calhoun studied the photograph. He grunted. "Could be stamped in worse molds," he allowed. He swiveled his chair to face her. "Rosario, right? What did you want to see me about?"

"Ursula Kitmann."

"Ah." Fingers made busy motions and the screen on his computer changed. He scanned it rapidly before focusing on her once more. "What about Kitmann?"

Jacinta took a deep breath. "I don't think you should expel her."

Calhoun blinked and glanced again at the document on his screen. "From what I've been told, I would have thought you'd be happy to see her go."

"I can't say we like each other very much; and I think she made a mistake coming back. Or at least, coming so soon after ... you know."

Calhoun cocked his head and his eyes became thoughtful. "Go on."

"You know she has an artificial arm?"

Calhoun nodded. "Among other things."

"Well, I sort of told her how she'd never be able to ... That because of her injuries, she'd ..."

Calhoun nodded. "I know."

"So it's my fault, in a way. If I hadn't made a point about her failing, maybe she wouldn't have gone out that night."

The superintendent sighed and pushed back from his desk. His gaze wandered to the class photographs on the wall. "Flight-testing airframes was the easier job. It doesn't hurt so much when one of those crashes and burns. Rosario, no one is responsible for what Kitmann did except Kitmann. She didn't have to buckle to your taunts. She didn't have to prove anything. Not to you and not to me, and certainly not to the others that were on that flight with her. *She* made the decision, and not all your guilty feelings can take that responsibility from her. Show her that much respect."

Jacinta had stiffened at the word "taunts." It hadn't been that way. But she wasn't here to defend herself. "You could give her another chance. She made a mistake, climbing the tower before she was ready; but she won't do it again.

"Damn right, but it'll be something else. It wasn't the physical handicap that did her in, Rosario. Work in ziggy is hard. It requires stamina, patience, and upper body strength. Trust me, I know. Body strength ... well, that was marginal, but we were working on a therapy program to bring it up. We don't insist that every-

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one go at the same pace. Stamina? She's got plenty of—"

"Fortitude."

Calhoun paused and looked quizzical.

"Fortitude," Jacinta explained, "is stamina of the mind. She's determined to see this through, no matter what. The others, they're calling her 'No Quit-mann'."

"Then I wish they'd find someone else to admire. Look, I'm not dropping her because she failed to finish the tower climb and fell on the way down. I'm dropping her because she showed bad judgement. Climbing at night? Alone? That's not fortitude, that's stupid! And we don't need stupid cadets—who push things because they don't have the patience to take them at their own pace."

Jacinta could see that the superintendent was adamant. The Face Like Flint. Eyes sad, but like bricks. It was all for the best, she told herself. Better that Ursula be disappointed now, when she could at least blame her own foolishness, than to be disappointed later, after she had given it her best shot. "Just one thing, Mr. Calhoun," she said as she rose. "If doing something stupid is grounds for expulsion, there isn't one of us safe for the term."

The smile the superintendent gave her was a sad one. "Including me," he said. "Including me."

Everybody said how the Super's decision was bump and maybe they ought to pull a strike, or run a demo, or hold a vigil, or something; but it was Kitmann herself who stuck up for Calhoun and said that if she'd been headmistress, she'd have done the same. But it was bump anyway. And, yeah, people die and loves die, but the hardest of all was when dreams die. Ursula had been kicked hard in her life, even before her parents' divorce, but had learned to land on her feet and plot her own orbit; and she kept going because her course was fixed on a lodestar that drew her on. Spaceflight. Piloting hot machines. Ziggy. And, maybe, seeing new worlds.

That was gone, now. Lost. And without that pole star, would she herself be lost? Jacinta didn't know. She didn't think she would ever know. And so, when Ursula's last day came, Jacinta checked a car out of the common pool and drove the woman to Bakersfield, where they got maudlin drunk together in the airport lounge and Jacinta apologized at last, because she had never once tried to find out if anyone had survived and had tried to wipe from her mind people the memory of whom was all that was left.

Lonzo Sulbertson showed up, and the three of them traded stories of this and that. They talked about ziggy and the Visitors and Mariesa van Huyten selling asteroids and whether the *Ares* would ever get built; about Tsiolkovky spinning up and Lonzo making his first moon flight in a few weeks. They talked about everything there was to talk about, except the last time the three of them had waited together for a jump jet in an airport.

Until the very end, when Ursula paused at the jetway and told them, "It's only the two of you left, now. Make us proud."

Then she boarded the jumper, and the rotors on the fan deck spun up and the plane lifted as gently as a leaf before the pilot kicked over the baffles and converted to horizontal flight.

Jancinta and Lonzo watched until the plane was out of sight. *I should be leaving, too,* Jacinta thought. *I don't belong here.* Then, sober, they sought their separate cars and drove back to the academy each alone. ◙

The heart is forever making the head its fool.

—François de la Rochefoucauld

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THE REFERENCE LIBRARY Tom Easton

Distraction, Bruce Sterling, Bantam, $23.95, 439 pp. (ISBN: 0-553-10484-5).

The Golden Globe, John Varley, Ace, $22.95, 425 pp. (ISBN: 0-441-00558-6).

Standing Wave, Howard V. Hendrix, Ace, $6.50, 387 pp. (ISBN: 0-441-00553-5).

The Tough Guide to Fantasyland, Diana Wynne Jones, DAW, $5.99, 302 pp. (ISBN: 0-88677-832-8).

The Merlin Mystery, Jonathan Gunson and Marten Coombe, Warner, $21, 48 pp. (ISBN: 0-446-52432-8).

First Contacts: The Essential Murray Leinster, Joe Rico, ed., NESFA Press (P. O. Box 809, Framingham, MA 01701), $25, 464 pp. (ISBN: 0-915368-67-6).

Robot: Mere Machine to Transcendent Mind, Hans Moravec, Oxford University Press, $25, 224 pp. (ISBN: 0-19-511630-1).

Countdown to Apocalypse: Asteroids, Tidal Waves and the End of the World, Paul Halpern, Plenum, $27.95, 270 pp. (ISBN: 0-306-45986-8).

Bruce Sterling is an excellent writer with an excellent reputation who has won only a single Hugo (in 1997, for "Bicycle Repairman") and no Nebula at all. The reason is not any shortcomings of his own but rather the superlative quality of the competition.

I think that's about to change. **Distraction** is Sterling's best novel to date. It's the one he's been working up to all along, and it's the one that will blow the socks off the competition this time for sure!

Sterling is using the idea of distributed processing, which is what makes the Internet work—no central control, just lots of connections and local decision making—to create a new vision of society that just might work, given lots of cheap computer chips. The best way to clarify this is surely to look at one of Sterling's central innovations: Alcott Bambakias is an architect who has developed a new building system. Stack up all the bricks and beams and sheets of paneling. Attach to each a small processor that can interact with global positioning satellites to know exactly where it is. Give it a speaker so that when someone picks up a stone block, it can say, "I am a cornerstone. Move me right . . . forward . . . left a bit . . . right there! Now put mortar on me." And unskilled labor can build elaborate structures very quickly.

A recipe for utopia? Well, maybe, but the Chinese have used the 'Net to destroy the whole concept of intellectual property. The economy has crashed. Global warming is flooding coastlines everywhere. Unemployment is near total, and there are vast mobs of nomads roaming the countryside, using bioprocessors to ferment food from weeds, pressing computer cases out of dried grass, living by barter, and ranking each other according to demonstrated and computer-collated trustworthiness.

Meanwhile Bambakias is now a U.S. senator, thanks to the genius of boy-wonder campaign manager Oscar Valpairaso, who has an unfortunate background problem—he was grown in a vat for the adoption market, his genetics aren't quite human, he has a high metabolism and body temperature, and he

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doesn't sleep much. Bambakias is wigging out, but Oscar is on vacation in the deep South, discovering that the governor of Louisiana, Green Huey, is using nomads to take over an unfunded Air Force base and finding a federal lab full of scientists who just want to be left alone to create miracles (they think, says Sterling, a lot like the nomads, as of course do the folks creating the Internet today—bureaucracy just gets in the way). Oscar and his krewe (everyone who is anyone has a krewe) now have a new mission, clearing out all the bureaucratic deadwood and making this place work, all while he gets it on with Nobelist Greta Penninger, who is deep into cognition, the next big thing. Meanwhile Green Huey is showing just what he can do with this cognition thing—would you believe multi-tasking brains?—and President Two-Feathers is starting a war with Holland.

Washington would dearly love to put all the pieces back together, but it can't be done. But that's OK. Sterling assures us that the future is cool: "Someday soon, the whole world is gonna be just like Louisiana. Because the seas are rising, and Louisiana is a giant swamp. The world of the future is a big, hot, Greenhouse swamp. Full of half-educated, half-breed people, who don't speak English, and didn't forget to have children. Plus, they are totally thrilled about biotechnology. That's what tomorrow's world is gonna look like—not just America mind you, the whole world. Hot, humid, old, crooked, half-forgotten, kind of rotten. The leaders are corrupt, everybody's on the take. It's bad, really bad, even worse than it sounds.... But you know what? It's doable, it's livable! The fishing's good! The food is great! The women are good-lookin', and the music really swings!"

Buy it. Enjoy it. Think about it.

I found John Varley's **The Golden Globe** more satisfying than his last, *Steel Beach* (reviewed here in March 1993). It's set in the same future, centuries after mysterious Invaders wiped humanity from Earth's surface, leaving only a few remaining space-dwellers to rebuild. Now Luna is the system's "Golden Globe," and people live on Mars, in the Belt, and elsewhere, all the way out to the Oort Cloud. There is even a protection-selling Mafia: the residents of Charon, the moon of Pluto once used as a dumping ground for vicious criminals and now home to the quintessential "vicious is fun!" gang.

Meet Sparky Valentine. Just a little kid whose father, the famous Shakespearean actor John Valentine, holds him under water until he remembers his lines. A little twitchy, sure, but that hasn't stopped him from becoming a child star, growing up, and living for a century as an itinerant actor. Of course, acting being what it is, he is sometimes reduced to performing Punch & Judy shows on the streets. Sometimes he even pulls the pigeon drop and other cons.

So here he is, on stage in the Oort Cloud, when a detective shows up looking for him. He runs—a habit of his, not too sensible when people are effectively immortal and doing a little time doesn't cost one much, but there's something unspecified in his past that keeps him scared—and soon he is purloining netsuke, fighting off indestructible Charonians, and getting closer to Luna, where long, long ago he built an empire based on the *Sparky and His Gang* TV show. His only companions are his dog Toby (which can be turned off and stored in Sparky's trunk as necessary) and the quite imaginary but still insightful Elwood P. Dowd. The journey is long, and Varley uses it to let Sparky remember his youth. By the time Luna looms, the reader has a pretty good idea of what revelations await. Or some of them, anyway.

The story is really in the memories. Valentine Senior was a driven, egotistical SOB. Valentine Junior was a victim who loved his daddy and knew a bit about

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how to get around him but could not avoid the final, cataclysmic confrontation, nor the crippling aftereffects. The rest of the book is a guided tour of a civilization as chaotic and vital as our own, which as in *Steel Beach* still owes a great deal to Robert A. Heinlein's precedent.

Sparky's both an entertaining scamp and a tragic hero, and Varley makes the combination work well enough. I enjoyed the tale.

In May 1998, I called Howard V. Hendrix's *Light Paths* "a barely controlled hodgepodge marred for most of its length by an enormous weight of expository dialog . . . interesting, but Hendrix has a ways to go before he's very readable."

The sequel—**Standing Wave**—is worse. It's virtually unreadable. But I forced myself to finish the cussed thing, and now I am going to tell you a little bit about the ordeal.

The tale begins with the return of the tepui (a Venezuelan mesa) launched into space by mushrooms, mental power, and infotech in the earlier book. The reason for the return is never made clear, but there it is, as are religious fanatics bent on exterminating environmentalists so the Earth can be used up as a necessary prerequisite for the Second Coming, a mass murderer who uses sudden floods of net-data to turn probers of forbidden databases inside out, several victims of government misuse of the tepui-launchers' sacred mushroom drug, artificial intelligences loose in the Net, and the Prince of Hackers, Phelonius Manqué. There are also an apparent comet with an uncometish tendency to change its course and more than a hint that some colossal intelligence has taken an interest in Earth and its people. Indeed, Phelonius Manqué is serving heavy time for his role in a catastrophe triggered by an attempt to concentrate data so hugely that it opens the Rainbow Door to heaven (the description made it look much like Hendrix thinks concentrated data equals mass, even to the point of a black hole; if you can swallow that, you can swallow those murderous eversions too). And when he gets loose, the Rainbow Door must of course come back into the story.

And in the end everyone from two novels is thoroughly apotheosized. Wow! Great stuff—at least, if you're into 'shrooms and mental powers and such and can tolerate vast lumps of laboriously expository infodump. It's overwritten, too, for Hendrix strains mightily for verbosely poetic lines such as "black as a necrotic squid tentacle" (just "black" would do; and the dead mollusc bits I'm familiar with aren't black at all).

Not recommended.

Diana Wynne Jones's **The Tough Guide to Fantasyland** is a pleasant little jape, a thoroughly tongue-in-cheek send-up of all—it's hard to imagine missing one in three hundred pages!—the clichés rampant in fantasy. Her chief points are that originality is rather scarce among the elves, wizards, and dragons and that fantasy writers rarely pay much attention to the fabric of their worlds (that is, they've read a lot more other fantasy novels than they have ecology and economics textbooks).

Fantasy fans with a sense of humor should enjoy this one. Ex-fantasy fans, who came to their senses, should enjoy it even more.

Is anyone working on a similar *Tough Guide to Sciencefictionland*?

If you wish to try a pair of interesting games, pick up a copy of **The Merlin Mystery**, by Jonathan Gunson and Marten Coombe. The first game is simply to see how many of Diana Wynne Jones's target clichés you can find. The second is the book's *raison d'être*: Be the first to find and decipher the clues concealed in the artwork and claim a crystal wizard's wand worth over $25,000 *and* a cash prize of over

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$125,000! Wow! That should sell plenty of books in the project's international marketing campaign.

Alas, the potential loot is the book's chief charm. The artwork is nice, intricate and evocative and apt. The story is only a short story, all about how Merlin's wand and accompanying magic shield the world against evil wizards who suborn even Merlin's one-time ward Nimue in their quest to conquer.

Be warned: Readers with dirty minds will find a pun in Nimue's yen for Merlin and her disguise as a black cat. They may even feel that the pun rather subverts an innocence that otherwise might leave the tale quite suitable for children.

Note that there is a companion music CD, *The Merlin Mystery*, by Alkaemy, from EarthTone Records (call 323-650-1000 or email merlin@earthtone.com for more information). The sampler that came with the book was pleasant enough in a New Agey sort of way, but I thought none of it very striking.

The latest in the New England Science Fiction Association's "NESFA's Choice" series is **First Contacts: The Essential Murray Leinster**. The series is dedicated to bringing "back into print classic science fiction that is essential to any good collection, but which is becoming increasingly difficult to find as the publishing industry's backlist shrinks." The books of the series are printed on acid-free paper and solidly bound, and NESFA says it plans to keep them permanently in print. So far the series includes work by Charles Harness, Zenna Henderson, James Schmitz, and Cordwainer Smith, every bit of it fondly remembered and much to be recommended.

The same goes for the Leinster work. As Hal Clement recalls in his introductory essay, Murray Leinster (Will Jenkins), whose work he first encountered in the 1930s, "was an idea writer at a time when an idea alone was likely to sell a story, but he liked to, and could, carry the idea to a reasonable and, if the reader were sufficiently on his or her toes, predictable conclusion. He was, in effect, writing science fiction mystery stories long before John Campbell said this was impossible." He was also knowledgeable, thoughtful, inventive, and prolific, and he had an immense influence on the many writers who came after him. And if Leinster's style seems a bit dated today, a great many of the stories remain fresh. Once again, NESFA has produced a book to be treasured. Buy two—one for yourself, and one to give your local library.

Hal Clement, by the way, is scheduled for a NESFA's Choice volume himself.

In his 1988 *Mind Children* (Harvard University Press), Hans Moravec sketched the future development of robots, proposed that within about fifty years it would be possible to transfer human minds into computers, and speculated on the replacement of biological intelligence by machine intelligence. To him, robots would be the creations of our minds just as our children are the creations of our bodies, and since it is our minds that make us most distinctively human, our "mind children" would be our children in the more important sense. At the same time, mind transfer would offer us true immortality.

In **Robot: Mere Machine to Transcendent Mind**, Moravec tells us that "Among many nice reviews of [the earlier book] an angry few brandished words like 'horrific,' 'nightmare' and 'immoral,' and at least one was too irate to publish." I find that curious, for to a mind steeped in science and science fiction since adolescence, Moravec's ideas are not terribly strange even if they do push the envelope of what even a visionary scientist might say.

Yet *Mind Children* was very much a part of a discussion of the potentials of artificial intelligence and robotics that began almost as soon as the first digital computers began chewing their bytes.

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Norbert Wiener invented cybernetics to "study brainlike activity in animals and machines." And in 1950, Alan Turing proposed that if one could not tell the intellectual difference between a computer and a human conversationalist, there was no such difference. The computer would be intelligent in the only way that matters.

Since then a great deal of effort has gone into meeting the demands of the "Turing test." So far success has been only partial, but there has been enough success to justify immense optimism in the minds of some, such as Moravec. On the other hand, others still resist the notion that a machine, a mere *thing*, could ever possibly really *think*. After all, it's too deterministic, quantum uncertainty is obviously essential to true thought, and it couldn't possibly have a soul, a mind, emotions, a sense of beauty, a . . . The list of deficits is endless; it also tends to be revised every time clever programmers figure out how to give a computer a new capability.

To some extent, *Robot: Mere Machine to Transcendent Mind* is a recapitulation and updating of the earlier book, reviewing the development of robots up to the point where they can take control of their own continuing improvement or evolution. Moravec devotes considerable space to what a civilization dominated by autonomous machines must mean for human economies. He does not shrink from the thought that most humans will be content to eat the lotus in idle bliss, supported by a horde of advanced robots programmed to be happy slaves. That won't last, though. Some folks will tire of idleness and give up their humanity to become "Exes," robots animated by transferred human minds, and hie off into the far reaches of the galaxy. After a while, they'll have to move fast when they leave Earth, for natural selection guarantees that our robotic servitors will give rise to more independent sorts, even to predators eager to absorb the materials, energy supplies, and even programs of anything—including Exes—that can't resist or elude them. In other words, there will eventually be a vast and diverse robotic "ecosystem" out in space.

In time, mere robots and Exes will be surpassed by superminds, which in turn will give way to what can only be described as an intelligent universe, a universe converted to computational apparatus and sheer mind in which all reality is virtual. Indeed, what he says is that within this vast "cyberspace," the "real" world will exist only as a simulation of itself. This includes plants, animals, and intelligent beings, and the simulation will be so perfect that no one will be able to tell the difference.

Science fiction readers, who have seen many of these ideas before, find them enchanting. Others find them terrifying, which explains some of the reactions Moravec receives, even from such scientific luminaries as Roger Penrose, who has spent a good deal of effort arguing against the idea of machine intelligence.

Moravec is too polite to call Penrose out in person, but he does borrow the form of Turing's seminal 1950 paper to attempt—like Turing—to lay to rest the various objections to the notion of machine intelligence. These objections he phrases roughly like so:

1. Machines have no souls, so cannot think;

2. Thinking machines cannot be possible, because the consequences would be too dreadful;

3. Mechanical reasoning is too limited;

4. Machines can have no inner experience to give meaning to their "thoughts" or actions;

5. Machines will never be kind, moral, joyous, perceptive, original, etc.;

6. Computers do only what we can program them to do;

7. Computers don't have nerve cells;

8. It is not possible to specify for a ma-

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chine what to do in every possible circumstance a human can encounter;

9. Computers can't have ESP (Moravec considers this a genuine nonissue but deals with it because Turing did).

Moravec is not always convincing, but I do not think it is possible to be more so. The immense leaps in the development of robots and artificial intelligence that he discusses cannot be predicted confidently given the present infantile state of the art. However, it is just as unreasonable for the opposition to say those leaps cannot be made. Both sides display an almost religious adherence to their beliefs. Certainly Moravec has faith in his dreams. His opponents have faith in tradition.

I'm inclined to side with Moravec, and I recommend *Robot: Mere Machine to Transcendent Mind* as a stimulating, provocative treat for your own mind.

Do you remember Isaac Asimov's *A Choice of Catastrophes: The Disasters that Threaten Our World* (Simon & Schuster, 1979)? It was an exhaustive review of everything—from *Revelations* to thermodynamics to plague and war and earthquakes—that could bring it all to an end. It even mentioned—twenty years ago!—the greenhouse effect, the damaging effects of chlorofluorocarbons on the ozone layer, and the disastrous potential of cometary impacts. But in the last twenty years, a great deal has been learned about such things. For instance, it wasn't till the 1980s that we learned it was an impact that did in the dinosaurs or discovered "nuclear winter." Only in the 90s were we able to watch Comet Shoemaker-Levy hammer Jupiter. Only now can we claim to see global warming in an apparently unending string of record warm years.

So it's time to remake the book, and here's Paul Halpern's **Countdown to Apocalypse: Asteroids, Tidal Waves and the End of the World**. It covers much of the same ground with due attention to scientific background in a very accessible way. There's more on millennial fevers, including the history of flagellators and "danse macabre" in medieval Europe, and much drawing of parallels with such as the Heaven's Gate cult. There's plenty on climate change and ozone and plague. All in all, a very nice repeat and update of the Asimov book.

However, there are some conspicuously missing elements. Halpern spends a fair amount of space on the Noachian Flood and its possible bases but fails to mention recent work suggesting that a rapid rise in the level of the Black Sea could have driven early agriculturalists out across Europe and the Near East with a heckuva tale to tell (you can find one account on the Net at http://betz.biostr.washington.edu/~jsp/facts/bosphorus-falls.html). Nor does Halpern mention three items that figure in Moravec's book above: the replacement of humanity by robots and of reality by simulation, and Tipler's Omega Point notion.

Well, one can't have everything. What Halpern does give us is well presented. This could be a very good book to give a high school student with a budding interest in science. ■

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BRASS TACKS

Dear *Analog*,

I want to tell you that the story in November 1998 issue of *Analog* by S.D. Howe, "Wrench and Claw" seemed as potentially memorable as the story Analog carried several years ago called *Mission of Gravity*.

Mission of Gravity awakened science fiction writers and scientists to the significance of a planet's (or star's) rotation and its potential impact on conditions on or around a planet or star.

"Wrench and Claw" should awaken science fiction writers and scientists on the potential significance of the millions of years in the past, and the potential for intelligence and civilization having been in existence on Earth prior to 65,000,000 years before the present.

Until I read "Wrench and Caw" I hadn't really considered how most anything fabricated by humans today would cease to exist in any recognizable form after sixty million years. It also pointed out just how primitive current archeology is.

I also enjoyed the Alternate View, by John G. Cramer, "The Music of the (Neutron) Spheres." The "fact" part of *Analog Science Fiction and Fact* is an important part of why I have been reading science fiction, ever since I discovered Edgar Rice Burroughs stories about a civilization on Mars written back around 1930. I enjoyed those stores more than the Tarzan stories. I've been reading science fiction, including *Analog*, almost since I learned to read (about 1928). Cramer's description of a neutron star made the concept of individual neutrons and what happens in neutron stars understandable.

Keep up the good work.

HENRY M. SALISBURY
(Retired aerospace reliability engineer)

Dear Stanley:

The occasion for this letter was Christopher Bennett's "Aggravated Vehicular Genocide" (November 1998).

I know, I know .... One must never suppose that the author agrees with any of his characters, however sympathetically they are portrayed. Maybe Bennett agrees with me that the court was wrong, that Stephen was a wimp for siding with the court, and that Cecilia's outrage was justified. If so, I salute his ability to write a story leaving such opposite impressions in the reader's mind. (No sarcasm intended, either.) I will not presume to know, Stanley, whether you think the court's judgment was right, but after reading a few dozen of your editorials I doubt it. In any case, I understand, too, that *Analog*'s editor would be wrong to reject a story just because it showed the good guys losing. By all the relevant criteria, "Aggravated Vehicular Genocide" is a good work of science fiction. It should have been published.

Notwithstanding all of the above, I am struck hard by this anomaly.

I discovered *Analog* in the early '70s. I have not read every issue since, but have seen maybe half—certainly at least one out of four. That gives us a ballpark figure of 100 issues, and therefore several hundred stories. Without taking the time to do the appropriate statistical tests, I think that's a pretty good sample. Not once, until now, have I read a story in which such extreme risk aversion was apparently vindicated.

I have read many stories advocating technological caution. I have read many stories warning against anthrocentrism. Never have I read a story that so effectively argued: "Don't take any

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chances, because somebody might get hurt." The tribunal's final argument rested on humanity's not needing ramjet technology for its survival. We were using it simply to indulge a preference that some of us will have for living on real planets. We were using it to maintain options, and to exercise those options. The tribunal apparently conceded, moreover, that we were using it as carefully as we reasonably could have been expected to use it. The tribunal's only problem, as best I can discern it, was that we had failed to reduce the probability of an accident to zero or, having failed that, to establish an absolute necessity for what the technology was to accomplish.

Following this argument, the Chirrn themselves would never have become spacefaring.

They would not even have become civilized. Our ancestors probably did not need to control fire or make tools to survive as a species. We certainly did not need to develop agriculture, or build cities, or invent writing. We may reasonably suppose that the Chirrn ancestors did not need to do any of these things, either.

In particular, the Chirrn did not develop their habitats in order to survive. They developed them to improve their quality of life. They could have stayed home and lived under Shayaln rule. They would not have like it, obviously, but they would have survived, and they would not have risked endangering anyone but themselves.

Their habitats did not present zero risk to other species. Surely some combination of malfunctions in sensors or propulsion could have resulted in Lesshchi's colliding with a planet and destroying whatever civilization might have been using it.

This is not to say that I found the judgment incredible for its inconsistency. Its reasoning was no more unsound than what many human courts would have used, or have used. I was surprised only that the author, through his characters, seemed to be endorsing such reasoning in the pages of *Analog*. Cecilia was right. The judgment was an expression of bigotry, not justice, no matter the mercy with which it was tempered.

Perhaps Bennett intended only to provoke such an analysis as this. Perhaps this was your intention, whatever his might have been. Whatever the case, I applaud you both. It was a good story. It upset me, but it was still a good story.

DOUG SHAVER

You're quite right that one must never suppose that the author agrees with any of his characters, though he may. In this case, I didn't ask him before buying the story where his personal sympathies lay; that was irrelevant and none of my business. What mattered was that history presented a very thought-provoking problem—and the mail has certainly borne that out!

The author replies....

First of all, I must disagree emphatically with Mr. Shaver's statement that the story argues "Don't take any chances, because somebody might get hurt." I am passionately against any such cowardly Luddism. Every technology has its benefits and risks, and it's irresponsible to sacrifice the benefits for fear of the risks.

But that's the key: responsibility. Responsibility doesn't mean that you take no risks; that's avoiding responsibility. It does mean, though, that you hold yourself accountable for risks that go badly. As Stephen said, a captain is responsible for her ship's wake. That means not only doing all she can to avoid damage, but also accepting liability for whatever damage is done anyway.

Perhaps the issue is how "responsibility" is defined. Is it blame, something that's imposed on you from without and only applies when you're provably in the wrong? Or is it something you de-

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mand of yourself with regard to your own actions, choices and relationships with other beings?

The other issue is the difference between necessary and unnecessary risks. The Chirrn position was that, since humans had viable alternatives to ramjets and to planetary living, the very use of a ramjet was an unnecessary risk, no matter how comparatively safe it was made. If someone were sued for property damage because they drove to the store in a tank—even though they followed proper tank protocols to the letter—what would be a fair verdict?

The question of prejudice goes both ways. Did the Chirrn's prejudice against planet-dwelling result in an unjust verdict? Or did the Humans' prejudice in favor of planet-dwelling result in the use of a needlessly dangerous technology?

So who do I feel was in the right? It's not that simple, and I didn't intend it to be. I feel there are strong arguments on both sides; otherwise I wouldn't have found the premise worth exploring. And I must say, I'm delighted to have stumbled across an idea which has stimulated so much lively discussion.

CHRISTOPHER L. BENNETT

Dear Stan:

Jeffrey Kooistra overstates his case quite a bit in the October '98 Alternate View. He seems to hold a "trendy" misconception about the nature of the scientific enterprise, that it's just another belief system. ("I think that in science ... we also believe what we want to believe.") He claims, for example, that it's "taken on faith" that the physical laws in distant galaxies are the same. This is incorrect. It's an assumption that seems reasonable because it's simple but nonetheless leads to consequences that agree with (so far) all observations. OK, maybe it's wrong. But wrong how? What observations are there to suggest otherwise? Sure, "the laws could be different," and we need to remember that their sameness is merely a working assumption. But that's all. In the absence of empirical data, speculating on "what it could be instead" is a waste of time; remember Occam's Razor. And metaphysics about "faith" miss the point completely.

Well, but then we really don't know! That's right. We really don't know that the sun's going to come out tomorrow, either, as far as that goes; but it seems a reasonable prediction based on a vast amount of empirical data.

Science isn't in the business of "proving" things, and Science (with that capital S) is not a route to absolute Truth (whatever that may be). It's a procedure for coming up with compact descriptions that both account for observations, and lead to predictions of new observations. Its justification is that this procedure empirically works. In fact, most scientists get very impatient with the metaphysical discussions of Truth—a fact that surprises many laypeople. Truth (capital "T") is not our business. Our business is describing, succinctly, how the Universe behaves.

(And yeah, it is assumed that there's an external universe out there to observe. Solipsism is not falsifiable, after all—but I can't take it seriously even so.)

On textbooks: now, I'm hardly a "textbook fundamentalist." If you teach a subject you know well (as I do), you're always finding errors in texts, particularly at the introductory level where the authors are trying to cover a lot of ground. Most such errors are minor, but occasionally there are doozies. (I delight in pointing these errors out to classes, by the way. Lots of naive undergrads are astonished that The Book is Wrong! Which is a good reality check ...)

That said, though, Kooistra is correct in saying that the purpose of textbooks is to present the consensus. But the reason it's a consensus is because it accounts for lots and lots and lots of observations!

Yeah, you have to "go to other sources" to find the anomalies; but to

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evaluate those anomalies, you also need to be thoroughly familiar with the observations that make the mainstream view mainstream. I don't excuse dogmatic pronouncements, much less name-calling; but I suspect that the "scientists and science fiction writers and readers" whose getting upset so puzzles Kooistra reflects an exasperation with a focus on "anomalies" with no sense of their context. Not all anomalies are to be taken seriously; they must be weighed in the context of the vast number of "non-anomalous" observations, and to do that you must have some appreciation of those observations and why they are assigned such weights.

For example, I mentioned in a previous letter that there's a host of geochemical, mineralogical, and isotopic data, derived from meteorites and interplanetary dust particles, that strongly suggests the asteroids were never a single body. This is one reason I (and most other scientists who have worked on planetary science) assign Van Flandern's "anomalies" little weight, and is why his notions are not mainstream. I suspect that Kooistra does not appreciate this data set, if he's even aware of it; but it must be considered even so! To be truly "paradigm shifty," new ideas must incorporate all observations, not just anomalous (and glamorous) ones.

(As an aside, Van Flandern would not be the first scientist with a largely mathematical background to dismiss geologic data because it's not "quantitative." After all, it consists of patterns and textures rather than numbers! But Van Flandern would also not be the first to make a serious mistake in doing so. Kooistra might want to look at Don Wilhelms' memoirs, *To a Rocky Moon* (Univ. of Ariz. Press, 1993). Wilhelms is a (now retired) geologist with the US Geological Survey, one of a group under the overall leadership of Gene Shoemaker who got involved with the lunar program in the sixties. Wilhelms recounts how a great many of the "hard" scientists didn't take the geologic observations seriously until the avalanche of data from the actual lunar samples forced them to. Harold Urey, a Nobel-winning chemist, was one of these; but to his credit, he finally (if grudgingly) modified his views and conceded that the geologists had been on the right track after all.)

In conclusion, I will be interested to see what "anomalies" Kooistra comes up with in subsequent columns; but I hope he spends at least as much time in familiarizing himself with why the conventional view is conventional. Without that sense of context, anomalies can hardly be considered paradigm shifty.

STEVE GILLETT

Stan:

Your November editorial gave food for thought, as always. If I might briefly speak up for hidebound constancy, there is one strong argument for minimal change in English (or any other language). You touched on it briefly when you said "the English of Chaucer is a long way from the English of today."

And how! The copy of "The Canterbury Tales" I'm currently holding is translated into modern prose from the original poetry, because the 600-year-old Middle English in which it was written is virtually impenetrable. One of the classics of English literature cannot be enjoyed in its intended form, save by a few linguistic scholars. The English language has passed it by.

A similar fate is close to happening to Shakespeare, 400 years old and heavily annotated in most editions to explain strange words and odd usages. Even my copy of "The Federalist Papers" has a five page glossary, spelling out different definitions for words we thought we knew. If you think I nitpick, look at the First Amendment, and consider the controversy created by the drifting definition of "establishment."

Every unnecessary change in our language erodes our connection with the past. (Note I say 'unnecessary'. Certainly

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we will need new words for new concepts. Even Latin has words for 'television' and 'computer' now, thanks to some unsung Vatican factotums.) Every time we lose comprehension of what old writers said, we are diminished. I think it worthwhile that, even as we expand our language to fit new ideas and creations, we take care not to change too much, and let more of the past fall beneath our horizon.

Shane Tourtellotte
smt@webspan.net

Dear Editor:

'One' is a third-person, singular pronoun:

" . . . if a car owner would rather choose a different set of risks, why shouldn't one be able . . . ?"

I agree 'one' sounds stilted, but 'one' is not wrong.

You could find safety in numbers:

" . . . if some car owners would rather choose a different set of risks, why shouldn't they be able . . . ?"

What about 'you'? There is only one of you, yet 'you' takes a plural verb because, in seventeenth-century England, 'you' replaced 'thou' for something very like politically correct reasons.

So completely have 'you' replaced 'thee' you do not even find it ironic when someone faults you for not observing number agreement, yet fails to address you as 'thou.' Why should 'they' not come to a similar pass?

Richard Lee Montgomery
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That's the point many readers missed: "they," like "you," appears to be acquiring an additional meaning in which it is a singular pronoun accepted in certain kinds of context.

Dear Stan,

The use of "they" or "them" for the indefinite singular pronoun isn't new, it's old.

In the OED (the *big, heavy* one . . . .) under "they" we find "(2) often used in reference to a singular noun made universal by every, any, no etc., or applicable to one of either sex (= 'he or she')." The following illustrative quotes go back to the 16th century.

So if people want to use a "rule book," the OED is one you can quote back at 'em.

"Thee" and "thou" are long dead, but I don't hear anyone bitching about using the second person plural for the second person singular. As you say, language is a dynamic construct and thus subject to change. And a creole language like English has very few rules anyway, except those imposed under the laws of contributing languages.

Many of our current "correct" usages were made up in Victorian times according to the rules of Latin—e.g. the double negative "rule" which is irrelevant in Germanic and Scandinavian languages (which are a part of English just as much as Latin, if not more so), or the split infinitive "rule," likewise (remember Churchill's famous response to a criticism about using a split infinitive, to the effect "That is the sort of interruption up with which I will not put"?)

Keep fighting the good fight—common sense, in both senses.

Robyn Daly

Dear Stan,

Constraints of space in my small flat have forced me to prune my bookshelves rather radically, including my collection of *Analog* magazines dating back to 1990 or so. I have been re-reading them, and putting aside those issues which contain stories I want to keep.

I was very much struck by a story in your August 1991 edition called "Enemy of the State" by Jack C. Haldeman. In this story, you may recall, the hero kept receiving e-mails from various organizations—from the supermarket, reminding him to buy fish food and so on; from the surgery, enquiring why he had been

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buying/using so much aspirin and encouraging him to have a check-up; from the library, telling him that the books he had reserved are now available, and so on.

The extraordinary thing is that with the advent supermarket loyalty cards, all the technology for this story now exists. It is now possible for supermarkets to monitor our purchases, and while they do not yet issue us with e-mail reminders to restock on certain goods, they do issue money-off reward vouchers that reflect our shopping preferences. Indeed, one major supermarket chain in this country has just set up as an Internet service provider, and a few of its stores offer grocery shopping via the Web.

Looking through my collection of *Analog* magazines has also brought home to me what a very recent development the Internet has been—only a very few years ago it was unheard-of, yet now you have your own website (as do I!) and its existence is a given as far as your magazine is concerned!

I do enjoy reading *Analog* every month—I could wish it was easier to get hold of in this country, but it makes a good excuse to visit my local science fiction bookshop

ANNABEL SMYTH

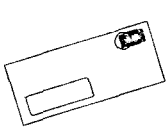
Dr. Schmidt,

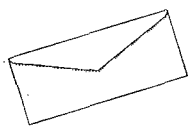
I am writing to congratulate you on the outstanding quality of your magazine. While I personally have been a subscriber for only a few years and have not the vast experience of many of your readers, I have found *Analog* to be a consistently good publication. In particular I would like to congratulate you on the quality of the social awareness in your magazine. I have ffiund the portrayal of women and homosexual styles of life to be unusually enlightened. I was surprised and pleased to find that homosexual characters are not merely oddities in the pages of Analog, but are regular characters. Further I was delighted to find that the fact of these character's homosexuality is not the point of the story, but may rather a side issue This open-minded approach to storytelling is a refreshing change from other fiction I have read which treats homosexual characters as sideshow freaks to prove their enlightenment.

The treatment of women in general within the pages of *Analog* has also been more than impressive. Not only have female characters displayed a variety of character traits, good and bad, but also are regularly fully developed characters. Whether the characters are protagonists or not they often surpass the caricature level too many writers become enmeshed in. Additionally the willingness to portray issues facing women, such as female genital mutilation in "Crossing Chao Meng Fu" has been highly admirable.

In closing, I have been very impressed in a very short period of time. While I would like to think that I can expect this level of forward thinking from all science fiction establishments, I have found that only a few of the very best publicat,ons truly live up to the standards of the next generation. Thank you for your fine effort and I look forward to the next issue.

MATT BRASHEARS ■





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UPCOMING EVENTS Anthony Lewis

1—4 April 1999
NORWESCON 22 (Seattle area SF conference) at the SeaTac DoubleTree Hotel, Seattle, Wash. Writer Guest of Honor—Harry Turtledove; Artist Guest of Honor—Richard Hescox; Fan Guests of Honor—Jack L. Chalker and Eva Whitley; Science Guest of Honor—Jack Horner. Registration—$50 until 1 February 1999, $55 at the door. Info—Norwescon 22, PO Box 68547, Seattle, WA 98168-0547. Phone—206.270.7850; email—nwc@eskimo.com

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2—4 April 1999
BALTICON 33 (Maryland area SF conference) at Baltimore Omni Inner Harbor Hotel. Guest of Honor—David Weber; Artist GOH—Jennifer E. Weyland. Registration—$40 until 13 March 1999, $45 at the door. Info—BALTICON 33, PO Box 686, Baltimore, MD 21203. Phone—410.563.2737; email—bsfs@balticon.org, URL—WWW: http://www.balticon.org

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2—4 April 1999
MINICON 34 (Minnesota SF conference) at Hilton Towers & Hotel, Minneapolis, Minn. Writer Guest of Honor—Octavia E. Butler; Fan Guests of Honor—Mark L. Olson and Priscilla Olson; Bookseller Guest of Honor—David Nee. Registration—$40 until 14 February 1999, $70 at the door. Supporting—$15 at all times. Info—Minicon, P.O. Box 8297, Lake Street Station, Minneapolis, MN 55408. email—council@minicon34.mnstf.org URL—http://www.mnstf.org/minicon34/

9—11 April 1999
5CON (5-college area-central Massachusetts SF and Fantasy conference) at Seelye Hall, Smith College, Northampton, Mass. Guests of Honor—Margaret Weis and Elizabeth Moon. Registration—$15 until 15 February 1999, $25 at the door. Info—5CON, 98 Green St. Box 8758, Northampton, MA 01063. email—alshaw@sophia.smith.edu; URL—http://www.smith.edu/ssffs/5con/

9—11 April 1999
I-CON (Long Island area SF/Media conference) at SUNY Stony Brook, Stony Brook, N.Y. Guests include—Lois McMaster Bujold, Harlan Ellison, James Hogan, Tim Powers, Ian Randal Strock. Info—I-Con, Box 550, Stony Brook, NY 11790-0550. Phone—516.632.6045; fax—516.632.6355; email—info@iconsf.org; URL—http://www.iconsf.org/

2—6 September 1999
AUSSIECON THREE (57th World Science Fiction Convention) at World Congress Centre, Melbourne, Australia. Guests of Honor—George Turner (in memoriam), Gregory Benford, Bruce Gillespie. Registration—$155 (A$225); supporting $35 (A$45) until 1 January 1999. [These are the latest posted rates and reflect the change in the Australia dollar as of the time this column went to press. Rates may go up after 1 January 1999.] This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Info—Aussiecon Three, GPO Box 1212K, Melbourne VIC 3001, Australia. US Agent—PO Box 266, Prospect Heights, IL 60070-0266. URL—http://www.aussiecon3.worldcon.org ■

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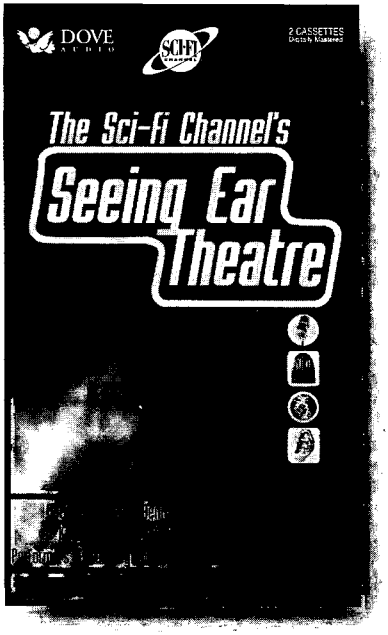

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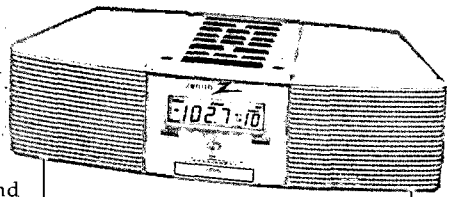

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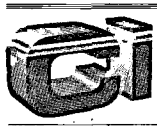

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